The Victorian Naturalist

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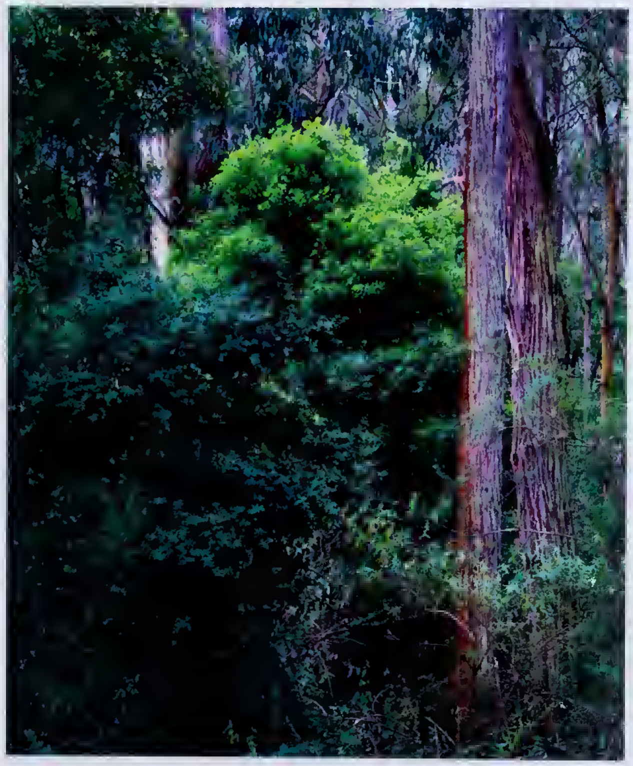

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From the Editors

This edition of *The Victorian Naturalist* continues the growing tradition of publishing the papers from the FNCV's annual Biodiversity Symposium in a single, 'special' issue. The most recent of these symposia, held in September 2006, focused on species that have become invasive. As noted in Dr Yen's Introduction to this collection of papers, invasive species are not necessarily introduced species; some native species have benefitted from various aspects of European settlement. This certainly is borne out in a couple of the papers published here.

A particular feature of this issue, unrelated to the bulk of papers, is the inclusion of an article detailing new combinations in some terrestrial orchids. Although received only recently, the passage of this article has been expedited through the editorical process because of the timeliness of its data. The soon-to-be-published newest edition of *Census of vascular plants of Victoria* will contain a reference to the new combinations first published in this issue of *The Victorian Naturalist.*

Looking ahead, the Editors are currently working on a second 'Special' issue for the year. Readers with an interest in entomology will be pleased to learn that the August edition will contain a collection of papers that concentrate on invertebrates.

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The Field Naturalists Club of Victoria Inc.
Registered Office: FNCV, 1 Gardenia Street, Blackburn, Victoria 3130, Australia.
Postal Address: FNCV, Locked Bag 3, Blackburn, Victoria 3130, Australia.
Phone/Fax (03) 9877 9860; International Phone/Fax 61 3 9877 9860.
email: fncv@vicnet.net.au
www.vicnet.net.au/~fncv

Address correspondence to:
The Editors, *The Victorian Naturalist*, FNCV, Locked Bag 3, Blackburn, Victoria Australia 3130.
Phone: (03) 9877 9860. Email: vicnat@vicnet.net.au

All subscription enquiries should be sent to FNCV, Locked Bag 3, Blackburn, Victoria Australia 3130. Phone/Fax:61 3 9877 9860. Email fncv@vicnet.net.au

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Front cover: *Pittosporum bicolor* (foreground, bluish-green), *Pittosporum bicolor* x *undulatum* (background, bright green) at Masons Falls, Kinglake National Park, Victoria. See article on p 117.
Back cover: Heavily damaged leaves of *Cyclamen* with Red-legged Earth Mites clearly visible. See article on p 117.

Introduction to the FNCV 2006 Biodiversity Symposium Issue: *Invasive species*

Alan Yen

Vice-President, FNCV

In 1981 the Field Naturalists Club of Victoria (FNCV) published a special issue of *The Victorian Naturalist* (Vol. 98 No. 1) that included articles about introduced mammals, trout, non-marine molluscs, introduced aquatic plants, weeds, boneseed and pigs. All of the plants and animals discussed are species introduced into Australia since European settlement and have become pests.

The concept of 'introduced' species is very much a blurred one, because 'introduced' and 'pest' are not necessarily synonymous. The deliberately-introduced biological control agents for some of these pests would not generally qualify as pests themselves. There are also native species that have become pests. For example, the Cootamundra Wattle is an environmental weed over much of south-eastern Australia. Some native species have become pests without translocation from one area to another; the Noisy Miner has become more common in remnants because fragmentation of woodlands and forests has resulted in conditions more favourable for this species.

This special issue of *The Victorian Naturalist* has a diverse range of papers. The papers by Gillbank, Robinson, Hingston and Weiss were presented at the 2006 FNCV Biodiversity Symposium on Sunday 10 September; the remainder were presented later as manuscripts. The topics covered range from the history of introductions of exotics by Ferdinand Mueller; the threats of invasive plants and animals to our environment; the measures used to control them; programmes that involve the general community in helping to prevent the entry and spread of these invasives; and future threats. These topics take in issues related to plants, animals and fungi.

The environmental and social consequences of the spread of these invasive species are well known. Many are now targets of containment or elimination programmes. Yet the elimination of an invasive species is not easy, and once an invasive species becomes established, eradication of it is nearly impossible. The main priorities today are to prevent the entry of invasive species in the first place, and this includes determining priorities based on the levels of risk that they pose.

The annual FNCV Biodiversity Symposium highlights different environmental issues that affect our native flora and fauna. Invasive species are a major threat, and these have become more apparent because of increased international travel and trade. The contents of this issue highlight the threats that we face but also provide some glimmer of hope that major incursions can be stopped early.

The FNCV wishes to thank all the presenters at the 2006 Symposium as well as those people who prepared written presentations for this issue. The FNCV also acknowledges the support of the Department of Sustainability and Environment for assistance with catering at the Symposium.

Of weeds and other introduced species: Ferdinand Mueller and plant and animal acclimatisation in colonial Victoria

Linden Gillbank

History and Philosophy of Science Department, The University of Melbourne, 3010
Email: lindenrg@unimelb.edu.au

Abstract

Prompted by nostalgia and economic hopes, but without an ecological understanding of the world, Ferdinand Mueller and other Europeans sought to 'improve' the Colony of Victoria by introducing useful and attractive species. As Government Botanist (1853-96), Mueller introduced an enormous diversity of foreign plants for cultivation and naturalization, and, while Director of Melbourne's Botanic Garden (1857-73), tested their colonial viability. From 1858 to 1861 Mueller was the honorary secretary of a management committee for a collection of birds and animals resident in the Botanic Garden; and, for the following twelve years, vice-president of a society which grew out of that committee – the Acclimatisation Society of Victoria, which was devoted to the introduction of species with economic and aesthetic appeal. Even after losing the Botanic Garden, Mueller continued to publicise and popularise the introduction of desirable plants, meanwhile providing weed information and advice. (*The Victorian Naturalist* **124** (2), 2007, 69-78)

Introduction

At a time of confident geographic, economic and scientific understanding of the world's flora and fauna, Europeans introduced 'new' animals and plants into the British colony of Victoria.

In the nineteenth century, Europeans depended on natural products to satisfy their needs, and saw the world as a collection of continents, islands and seas harbouring the plants and animals which would provide their foods, medicines, fibres and timbers. Europeans explored and exploited the world. They pilfered a remarkable array of organisms, and developed and refined taxonomic systems to classify them. They established colonial botanical gardens to trial the cultivation of plants with economic potential, often in regions with climates very different from that of the imperial power. As European tastes and technologies expanded to value and process an increasing diversity of the world's flora and fauna, oceans were criss-crossed with shiploads of species destined for new landscapes. By the mid-nineteenth century a taxonomic system provided a universal lexicon of plant names and a framework within which new species could be established, and the term 'habitat' was understood in the proto-ecological context of phytogeography.

When post-Enlightenment European minds met post-Gondwanan Australian landscapes, the human manipulation of these landscapes over many millennia and their evolution across unimaginable eras remained unseen. Europeans saw peculiar plants and animals which challenged their concepts and taxonomic systems. They also saw the young antipodean colony of Victoria as sadly deficient in useful and attractive creatures, and rose to the laudable challenge to 'improve' it with introductions of the world's floral and faunal treasures. And they harboured a gnawing nostalgia for the sights and sounds of 'home'. Furthermore, as waves of job-seeking immigrants left depleted goldfields in the late 1850s, Victoria's government and swollen populace were anxious to find new industries. What 'new' animal or plant could graze or grow in the growing colony? A scientific society, the Philosophical Institute of Victoria, and the Government Botanist and sometime Botanic Garden Director would help.

Plants

Dr Ferdinand (later Baron von) Mueller was Victoria's Government Botanist for most of the second half of the nineteenth century – from 1853 until his death in 1896. From 1857 until his directorship was abolished in 1873, he was also, with no additional salary, Director of Melbourne's

Botanic Garden.

Dr Mueller soon expressed his optimistic vision for Victoria's future prospects, concluding his second annual report as Government Botanist that, with 'the serenest climate', 'no praise too high' could be bestowed 'on the productiveness of our adopted country'.

> We possess in the Southern hemisphere, what the Ancients in the Northern called "regiones felices," those happy latitudes of a warm temperate zone, in which Nature with a prodigal hand offered prominently, amidst so many other gifts, the Cerealia, the Olive, and the Vine, and to which we there have added from the far East, the Orange, the Tea; from India, the Rice; and from the New World, the Maize, Cassava, Arrowroot, Tobacco, and so many other treasures of the vegetable world, on which mankind now rely for luxury and support. All these may be here successfully produced along with those which we enjoyed in the country of our youth, and will, I trust, with the mighty resources of our mineral wealth, render this country one of the most delightful and prosperous of the globe (Mueller 1854: 7).

As he later explained:

> In all zones, except the most icy, mankind depends on plants for its principal wants. For our sustenance, clothing, dwellings, or utensils; for our means of transit, whether by sea or land; indeed, for all our daily requirements, we have to draw the material largely – and often solely – from the vegetable world. …
>
> To render, therefore, these vegetable treasures accessible to our fullest benefit, not only locally but universally, must ever be an object of the deepest significance (Mueller 1871b: 58).

Mueller devoted much of his working life to encouraging and facilitating the introduction of the world's vegetable treasures into Victoria, presenting his ideas about desirable plants in lectures and reports. In a public lecture in 1870, he described his species-enriched vision splendid of Victoria's mountain valleys:

> Might not the true Tulip tree, and the large Magnolias of the Mississippi and Himalaya, tower far over the Fern trees of these valleys, and widely overshade our arborescent Labiatae? Might not the Andine Wax Palm, the Wettinias, the Gingerbread Palm, the Jubaea, the Nicau, the northern Sabals, the Date, the Chinese Fan-palms, and Rhapis flabelliformis, be associated with our [*Livistona*] Palm in a glorious picture? Or turning to still more utilitarian objects, would not the Cork tree, the Red Cedar, the Camphor tree, the Walnuts and Hickories of North America, grow in these rich, humid dales, with very much greater celerity than even with all our tending in less genial spots? Could not, of 400 coniferous trees and 300 sorts of oaks, nearly every one be naturalised in these ranges, and thus deals [planks], select tanning material, cork, pitch, turpentine, and many other products, be gained far more readily there than elsewhere in Victoria, from sources rendered our own?

He affirmed that

> of about 10,000 kinds of trees, which probably constitute the forests of the globe, at least 3000 would live and thrive in these mountains of ours; many of them destined to live through centuries, perhaps not a few through twice a thousand years, as great historic monuments (Mueller 1871b: 60-1).

A month after his August 1857 appointment as Director of Melbourne's Botanic Garden, Dr Mueller addressed Victoria's respected Philosophical Institute on the subject of desirable plant introductions. In response to numerous inquiries, he wished 'to draw attention to some of the most useful plants deserving either introduction into this country or a wider diffusion throughout our territory', and discussed an enormous number of trees and other plants from the subtropical and colder girdles of the globe. Since 'a large proportion of our population is returning gradually from a migratory life [gold-seeking] to the firm abodes of settled communities,' he suggested that 'the time has arrived, when our thoughts should be directed, not only to the means of our present, but also of our future prosperity' (Mueller 1858a: 93).

The Botanic Garden was an essential accessory for the Government Botanist. He needed it to test the ability of plants to grow in Victoria, and to propagate plants and collect seeds for distribution across the Colony. Mueller's first annual report as Government Botanist records the Garden's importance 'for the experimental introduction of foreign plants into our adopted

country' (Mueller 1853: 7). The German-born discipline of phytogeography, which sought explanations for the climatic shaping of the world's vegetation, underpinned Mueller's understanding of the essential role of a botanic garden as a place to test-cultivate plants from similar climatic zones (Jeffries 1997), and led him to seek (unsuccessfully) experimental gardens in other climatic regions of Victoria (Home *et al.* 2002: 333-4, 405, 628). His first report as Director of the Botanic Garden concludes:

> when it is considered that under the mildness of our climate we may choose from the endless number of plants of the whole temperate and subtropical zone, and that even many from the warmest parts of the globe may be acclimatized in our latitudes, it will then be needless to show how wide a field is left for our progress, and we may trust that many of the future introductions into our Garden will not be without practical value to the Colony (Mueller 1857: 8).

Mueller's annual reports include long lists of seed and plant donors, thirty botanic gardens and over 150 individual donors being recorded for 1860 (Mueller 1861: 3-4).

Mueller sought all manner of useful plants to test their suitability for colonial cultivation or naturalization. Some of those he mentioned in his substantial Philosophical Institute paper were already growing in the Botanic Garden. His annual report for 1858 records the following eclectic collection:

> various Spice plants, the Tallow tree, the Nettle tree of Illawarra, the Desert Clianthus (which was figured as a notable flower already by Capt. Dampier), the Bottle tree of Sir Thomas Mitchell, the Litchi tree, the Cherimoir, the Banyan tree, the tall Pampas grass, the prolific Prairie Festuca, the edible Hovenia, the Gunyang, the Staranis, the Paraguay and Chinese Tea, the Camphor tree, the Tulip tree, Waratah, Bananas, the American Sarsaparilla, the Cork tree, the Giant Pine of California, the Cochineal Cactus, the Chinese Grass-cloth plant, the Australian and Indian Rotang, the Coffee tree, the Cotton plant (which now without protection occasionally ripens its pods), the Red Cedar, the Kaurie Pines from East Australia, Polynesia, and New Zealand, Bog Bean, Acorus, Nelumbium or Sacred Pythagorean Bean, many medicinal plants, &c (Mueller 1858b: 7).

These and other useful plants are among the 3300 species listed in the 'Catalogue of plants under cultivation in the Melbourne Botanic Garden' which Mueller appended to his 1858 report.

During his sixteen years as Director, Mueller oversaw the cultivation of many thousands of plant species in Melbourne's Botanic Garden. His aim was always

> to give precedence to *utilitarian and industrial culture*, while less attention was bestowed on mere ornamental cultivation … I kept the requirements of a *young country* in view, where the extensive distribution of new industrial plants, such as Cork Oaks, American nut trees, Assam and Chinese tea &c, is needed far in preference to the ephemerous show of florist flowers (Home *et al* 2002: 517).

In the 1860s visitors to the Botanic Garden could see all sorts of medicinal, food and fibre plants, and, in the Garden and the adjacent Government House Reserve, enjoy the umbrageous beauty of avenues and plantations of an impressive diversity of coniferous and deciduous timber trees.

Animals

Under Mueller the Botanic Garden contained more than plants. Initially there were birds on the lagoon and in the shrubbery (Mueller 1857: 8). Then an aviary was added, prompted by an Institute talk by Edward Wilson, gentleman farmer and co-owner and retired editor of Melbourne's newspaper, *The Argus*.

In April 1857, Wilson discussed his orchestration of the transfer of the Murray Cod to the Yarra River – his own small correction of the 'unequal and even eccentric' distribution of Nature's creatures. 'With a virgin country, an Italian climate, and British institutions to lend force and intelligence to our endeavours', Wilson (1857a: 24) shared Mueller's hopes for vast and varied economic and aesthetic improvements, and pointed out that

> Nature seems to have been lavish in the supply of her various gifts, but singularly capricious in their adjustment; or rather she has properly and kindly left to man the interesting and agreeable task of supplementing her own efforts, of discovering by experi-

> ment and the action of his own intellect how far the gift itself may be multiplied, extended and improved (Wilson 1857a: 25).

In a subsequent Institute paper on the introduction of such welcome British songbirds as canaries, skylarks and nightingales, Wilson (1857b: 86) explained that he had 'no idea of living in a half-furnished country'. His talk prompted the formation of the Institute's Song Bird Committee (which included Wilson) to consider future symphonic introductions. Following Mueller's recommendation, the Committee's request for government funds for the erection of an aviary in the Botanic Garden was successful (Maroske and Gilfedder 1994). Meanwhile, Wilson became a founding committee-member of the new Zoological Society of Victoria, which was established in October 1857, and sailed for England, where he began orchestrating the transmission of birds to Melbourne.

Early aviary residents included canaries, goldfinches, chaffinches, siskins, linnets, Java sparrows, nightingales, skylarks, blackbirds, thrushes, Manilla doves, partridges, larks, starlings, hedge sparrows, Fiji pigeons, ring doves, ortolans, Ceylon doves, turtledoves – many sent by Edward Wilson (Maroske and Gilfedder 1994). The purpose was more than display. Birds were to be liberated in the Botanic Garden and beyond. In September 1858 Mueller informed the Philosophical Institute that 'the birds are mostly prospering, and there are many young canaries'. With a view to setting loose a large number of birds for naturalisation, he besought Institute members and their friends for donations of female goldfinches and linnets, and also thrushes, blackbirds and nightingales (Philosophical Institute of Victoria 1858).

Mueller reported that the aviary (Fig. 1), which had 'become very attractive to the public', was 'placed in the dense shrubbery of the valley between the rustic bridge and the lake, in order that the sight and song of the birds may be fully enjoyed without disturbing them'. It housed a large number of birds 'entrusted to our care by the Philosophic[al] Institute, with a view of effecting the domiciliation of the young birds in our garden, and thereby gradually a general distribution of foreign song birds over Australia' (Mueller 1858b: 4). A second wing was added during 1859, 'the whole dry and shady space below the bridge thereby becoming available as a secluded spot for brooding birds' (Mueller 1860a: 3). Unfortunately a trial sanctioned by the Institute's Committee 'to naturalize foreign singing birds, by setting them at liberty in our shrubberies' was not successful. Gradually,

> although well provided with food, the number of the liberated birds decreased, and at last they entirely disappeared. In an attempt to naturalize the more hardy thrushes [from Wilson], we may anticipate to be more successful, particularly if at the proper season, the birds are at once transferred to suitable spots in the forest ranges, or perhaps to some of the islands (Mueller 1860a: 8).

Although many birds suffered badly during the long sea voyage to Melbourne, ornithological expectations and experiments continued. During 1860 many pairs were liberated 'near the Yarra Bend Asylum, on Phillip Island, Sandstone Island, and Churchill Island', as well as in the Botanic Garden, or 'distributed to gentlemen who had constructed aviaries sufficiently spacious and secure to render the prospect of the increase of these birds rather hopeful' (Mueller 1861: 9).

Meanwhile the Philosophical Institute agreed to hand over its incoming birds to the young Zoological Society, which, without promised government funds, was unable to develop its own rather swampy grounds on the northern (Richmond) side of the Yarra River, leaving its small, but growing, menagerie accommodated in the aviary and an enclosure in the Botanic Garden on the other side of the Yarra. Ferdinand Mueller and Frederick McCoy, Professor of Natural Science at Melbourne's young University, were two of the four government nominees on the committee established in mid-1858 to manage the impecunious Society's creatures – the Zoological Gardens Management Committee, which received the £3,000 earlier promised to the Zoological Society (Gillbank 1996a; 1996b). As the Committee's Honorary Secretary from 1858 to 1861, Dr Mueller sought useful animals and, as Botanic Garden Director, continued to seek, grow and distribute useful plants.

Fig. 1. The aviary in Melbourne's Botanic Garden, photographed by Ed Haigh in 1861. Picture Collection, State Library of Victoria.

When the Zoological Society's land was incorporated into the Botanic Garden, Mueller could sign his annual report as Government Botanist and Director of the Botanic and Zoological Garden. By 1860 the mainly donated exotic faunal residents included llamas, Angora goats, fat-tail sheep, elk, fallow deer, Sumatra deer, Ceylon deer, four species of monkey and English squirrels, as well as various water-birds and songbirds (Mueller 1861: 10). The arrival of 46 thrushes and llamas (in a mixed llama-alpaca flock) from Edward Wilson, prompted Mueller to report that

> the disinterested zeal, the circumspect care, and patient perseverance of that gentleman, for the introduction of the treasures of the animal kingdom into this country, cannot receive a sufficiently high eulogium. To his exertions, supported by some friends of the colonies in Britain, we owe principally the donation of our llama-alpaca flock (Mueller 1860a: 8).

In his presidential address to the Philosophical Institute (almost Royal Society) of Victoria, Mueller (1860b: 5) commended Edward Wilson's zoological zeal, and expressed his own continuing high hopes:

> Might not the vegetable treasures from every zone, except the torrid, be flourishing around us, ministering to our necessary wants and to our luxurious enjoyment? Might not the pastures of our silent Alps, might not our grassless forest-ranges, like the Andes or the Himalayan mountains, yet be enlivened by the alpaca or the Cashmere goat? Might not the desert game of Southern Africa yet roam in lively sport throughout our inland solitudes, and render them more hospitable, perhaps betraying to the wearied wanderer, by their path, the water-pool on which his life depends? Might not the camel's track across the continent guide with their flocks the harbingers of new colonization to the oases of our inland wastes ... (Mueller 1860b:3)?

Government funds allowed the Zoological Committee to acquire expensive animals. At great government expense, two dozen camels arrived in 1860, and in August set off from Royal Park with Burke and Wills and the rest of the Royal Society's over-encumbered expedition to cross the continent – just as Royal Park was being considered as an alternative site for a menagerie (Gillbank 1996b).

Fresh from participating in the establishment of an English acclimatisation society, the eagerly-awaited Edward Wilson returned late in 1860 to a Melbourne well-set for acclimatisation, and quickly became a member of the Zoological Gardens Management Committee, which was now the provisional committee of a new society dedicated to something much grander than mere menagerie management – acclimatisation. The Acclimatisation Society of Victoria was the third such society in the world, and, like the English society, echoed the aims and aspirations of the earlier-established French society (Gillbank 1986).

The Acclimatisation Society of Victoria (ASV)

Melbourne's new society echoed the hopes and aspirations of resident Europeans. It would seek to satisfy their economic and nostalgic desires by orchestrating the introduction of plants and animals of use and pleasure. Arising on a wave of enthusiasm for animal and plant acclimatisation, it was an organisation truly of its time, and sought

to complete the work which Nature had apparently left incomplete in Australia. It had high ideals and huge hopes.

The Acclimatisation Society of Victoria (ASV) was formally established at a public meeting presided over by Victoria's governor, Sir Henry Barkly, on 25th February 1861. With Henry Barkly as Patron and Edward Wilson President, Ferdinand Mueller was Vice-President, a position he held from 1861 to 1872. The ASV attracted members, and funding and land from a government willing to continue supporting the zoological enterprise. Angora goats, Chinese sheep, llamas and alpacas were transferred to the patch of Royal Park permanently reserved for zoological purposes, to become the nucleus of the ASV's zoological collection, leaving birds singing in the aviary and swimming on the lagoon in the Botanic Garden. To the dismay of many Melbournians, the main purpose of the ASV's zoological gardens was not the display of animals. Instead they were a staging depot where sea-weary animals could rest and hopefully breed, while awaiting transfer to a rural property or liberation in the wild (Gillbank 1996a; 1996b).

With its council including scientists, doctors, lawyers, newspapermen and wealthy farmers and pastoralists, the ASV exuded influence; and sister societies were established in other Australasian colonies (Gillbank 1986). In its first annual report, the ASV Council expressed gratitude for 'the liberality of the Legislature' and confidence that continuing government support would result in

> the aggrandisement of the colony, and the multiplication of its industrial resources, while its attractions as a place of residence will be materially enhanced when it offers to the lover of nature and the sportsman the same sources of pastime and enjoyment with which he was familiar in the country from which he emigrated … . No country in the world is so favourably circumstanced for acclimatisation purposes as Victoria, and it is within the power of its inhabitants to enrich it by stocking its broad territory with the choicest products of the animal kingdom borrowed from every temperate region on the face of the globe (Acclimatisation Society of Victoria 1862: 9).

The ASV tried to please everyone. For the pastoralist it offered the alpaca, Angora and Cashmere goat; for the sportsman deer, elk, hare, quail and various ducks; for the angler salmon, trout, carp and other fish; and for the agriculturalist, such supposedly grub-eating birds as the thrush, blackbird, starling, sparrow and Common (Indian) Myna.

Professor Frederick McCoy, delivered the ASV's first anniversary address in November 1862, explaining that acclimatisation was

> *the bringing together in any one country the various useful or ornamental animals of other countries having the same or nearly the same climate and general conditions of surface (McCoy 1862: 36).*

He had a gastronomic slant on biodiversity, and particularly valued those cud-chewing, hooved quadrupeds, the ruminants, which include sheep, goats, cattle, deer and antelopes. Explaining their meat-producing importance, Professor McCoy revealed the 'extraordinary' fact that

> while Nature has so abundantly furnished forth the natural larder of every other similarly situated country on the face of the earth with a great variety, and a profusion of individuals of ruminants good for food, *not one single creature of the kind inhabits Australia!*

Furthermore,

> If Australia had been colonised by any of the lazy nations of the earth, this nakedness of the land would have been indeed an oppressive misfortune, but Englishmen love a good piece of voluntary hard work, and you will all, I am sure, rejoice with me that this great piece of nature's work has been left to us to do (McCoy 1862: 39).

He mentioned arrangements for the acquisition of the highly-prized eland and other South African antelopes, and the anticipated arrival of a flock of the valuable 'pure Cashmere-shawl goat, from Thibet', purchased by the ASV

> with the intention of forming a great herd on some of the highest mountains of Gipps Land which retain snow sufficiently long to produce the temperature necessary for preservation of the finest qualities of the wool and hair' (McCoy 1862: 50).

In the 1860s Professor McCoy helped the ASV introduce the Cashmere goat and two

other creatures from India – the Arrindy silkworm and the Indian Myna. While Dr Mueller continued to distribute white mulberry trees, which the ASV hoped would eventually support a silk industry, the introduction of the Arrindy silkworm, which lives on the castor oil plant, was unsuccessful. The ASV had the supposedly grub-consuming Indian Myna and other 'precious' introduced birds given legal protection from shooting (by listing them under Victoria's game act). Farmers, however, did not appreciate their fruit-consuming propensities, and, despite McCoy's continuing praise of their grub-eradication value, the ASV decided not to oppose the removal of sparrows and mynas from legislative protection in 1871 (Gillbank 2001).

By then public criticism of Melbourne's Botanic and Zoological Gardens was escalating. The Botanic Garden was not beautiful enough. The ASV's menagerie was not exciting enough. In a public lecture in 1871 Mueller discussed the importance of a botanic garden in bringing together 'the greatest possible number of select plants from all the different parts of the globe' and their scientific, geographic and economic display. By 'the introduction of novel utilitarian species, local industries are to be extended, or new resources to be originated', and public interest generated in the utilisation of plants and their products (Mueller 1872a: 6). But this was apparently not what the public wanted. Just as Baron Ferdinand von Mueller was being ousted from his too scientific and instructive Botanic Garden (Cohn and Maroske 1996), the ASV acknowledged its zoo-keeping role and became the Zoological and Acclimatisation Society of Victoria and began seeking more interesting animals for its Zoological Gardens.

Nevertheless the Society published Mueller's papers on timber trees and other plants 'readily eligible for Victorian industrial culture, with indications of their native countries and some of their uses' (Mueller 1871a, 1872b, 1874, 1875, 1878), which he prepared 'with a view of promoting the introduction and diffusion of the very many kinds of plants, which in our geographical latitudes may be extensively reared in forests, on fields or pasture' (Mueller 1876: iii). Seeking a wider audience for this important information, he gained ministerial approval for a departmental publication – his 293-page book, *Select plants readily eligible for industrial culture or naturalisation in Victoria, with indications of their native countries and some of their uses* (1876), in which he sought to bring together 'some condensed notes in popular language on all the principal utilitarian plants hitherto known to prosper in extra-tropic zones' (Mueller 1876: iii). Since the information was relevant to other temperate parts of the world, Mueller removed 'Victoria' from the title and added 'extra-tropical', and edited and enlarged it for NSW, Indian, American, German, French and Victorian editions in the 1880s. The 1885 Victorian edition of *Select extra-tropical plants* contains 466 pages of information about useful alien and Australian plants. Not surprisingly, it does not include thistles and other acknowledged weeds.

Weeds

Mueller was affronted by the accusation that he had introduced weeds into Victoria. Certainly Capeweed *Arctotheca calendula* (= Cryptostemma *calendulaceum*) was a glaringly obvious problem in the Botanic Garden, but Mueller pointed out that, on his arrival in 1852, it was already widely established around Melbourne (Maroske 2005: 178). And he knew that it had been recognised as a Victorian weed long before that. Since he had 'repeatedly been accused of having brought this and other weeds' into the Colony, Mueller (1869: 10) reported that these assertions were 'contrary to facts, and that already, in 1833, Baron Von Huegel noticed and recorded the cryptostemma as an inexterminable weed of Australia'. In a public lecture, he mentioned the 'Cape Weed, for the presence of which I am not responsible, as it had already irrepressively invaded some parts of Australia as early as 1833' (Mueller 1872a: 29). Before moving to Victoria, Mueller had observed and collected it in South Australia, recording on his herbarium specimens its common occurrence round Adelaide in 1848 (Kloot 1983: 112).

Mueller was aware of weeds as soon as he arrived in Australia. While collecting and documenting the South Australian

flora, he recognised familiar plants proliferating in disturbed areas round Adelaide and in rural farming areas – plants which, unlike Capeweed (from South Africa), were well-known weeds in Europe (Kloot 1983, 1987). Victoria's National Herbarium (MEL) holds specimens of weeds Mueller collected in various parts of South Australia in the late 1840s, some of which include annotations such as 'on roads, waste places and cultivated land around Adelaide' for Wireweed *Polygonum aviculare* (Kloot 1983: 118).

When South Australia's *Thistle Act* 1851 was passed, Mueller estimated that about 100 plant species (from Europe and the Cape of Good Hope) had become naturalised 'beyond the possibility of extirpation' in South Australia (Kloot 1983: 98). Aimed at preventing the further spread of plants commonly known as the Scotch Thistle, the Act covered purple-flowered thistles, but not the true Scotch Thistle, which was not common in South Australia (Kloot 1987: 88).

Victoria's Thistle Bill was passed in 1856, while Mueller was away on a British expedition across northern Australia. 'An Act to make provision for the eradication of certain thistle plants and the Bathurst Burr' (1856) covered four purple-flowered thistles well-known in Europe – Spotted Thistle, *Carduus Marianus*, Sacred Thistle, *Carduus Benedictus*, Spear Thistle *Carduus Lanceolatus*, and Scotch Thistle *Onopordon Acanthium*, – and the Bathurst Burr *Xanthium Spinosum*, from South America (Parsons 1973: 14). In 1861 Mueller warned that 'unless the growth of the thistles becomes methodically checked, their number will year after year be vastly increasing until it may finally [be] almost beyond possibility to arrest the progress of these weeds', and advised that the Thistle Act should be rigorously enforced on private land and tenders should be hired to deal with weeds on Crown land (Maroske 2005: 176).

When amendments to Victoria's 1865 Thistle Prevention Statute were being considered, Mueller recommended the removal of the Holy or Sacred Thistle, which had 'never been really abundant' and had 'lately almost disappeared', and the addition of the troublesome Creeping or Perennial Thistle *Carduus arvensis*, 'on account of its creeping *perennial* root, which is very tenacious of life' (Home *et al.* 2002: 590-591). Mueller was aware that Wireweed (sometimes called Knot Weed), docks and other weeds were spreading but, because their seeds were neither as readily wind-dispersed as thistle-down nor as readily transported by stock as the Bathurst Burr, he would not seek their inclusion under the Act 'unless many other troublesome weeds, such as the Burr Clover *Medicago denticulata*, the South European Star Thistle *Centaurea Melitensis*, *Cryptostemma calendulaceum* and many other weeds, were also included in the operations of the act' (Home *et al.* 2002: 592). Mueller's suggestion for the addition of weeds 'deemed by the Government Botanist as sufficiently noxious to be operated against in conformity with this act' (Home *et al* 2002: 591), was echoed in the 1891 Act, which allowed plants to be proclaimed 'thistles' without requiring an amendment (Parsons 1973: 14).

To facilitate recognition and understanding of plants whose destruction was required under the Thistle Act, Mueller (1893) prepared an illustrated booklet on the nine species

- *Carduus Marianus* Spotted Thistle
- *Carduus lanceolatus* Spear Thistle
- *Onopordon Acanthium* Scotch Thistle
- *Xanthium spinosum* Bathurst Burr
- *Carduus arvensis* Perennial Thistle
- *Carduus pycnocephalus* Shore Thistle
- *Centaurea Calcitrapa* Star Thistle
- *Centaurea Melitensis* Malta Thistle
- *Kentrophyllum lanatum* Saffron Thistle

All are listed in Mueller's 'Plants, hitherto immigrated and naturalized in Victoria, with indications of their nativity and English popular names' in his *Key to the system of Victorian plants* (1888). Mueller did not include their descriptions because most of the 171 listed naturalized aliens, being widely distributed in Europe, were described in publications on the British flora, which were readily available in Victoria. The list also includes other weeds, such as Capeweed, *Arctotheca calendula* Knot-Weed *Polygonum aviculare* Burr-Clover, *Medicago denticulata* and the docks *Rumex crispus* and *Rumex conglomeratus*.

Not all the listed naturalised aliens were undesirable weeds. Mueller (1885) described over a quarter of them in his *Select extra-tropical plants, readily eligi-*

ble for industrial culture or naturalization, including Chamomile, Parsley, Chicory, Samphire, Artichoke, Fennel, Lettuce, Horehound, Alfalfa or Lucerne, Penny-royal, Tree-Tobacco, Parsnip, Castor Oil Plant, Rosemary, Salad Burnet, Salsify, Gorse or Furze, Vetch and various clovers and grasses. The entry for Horehound *Marrubium vulgare* includes good and bad attributes – 'in many countries quite a weed … Its naturalization can nowhere be unwelcome, as it does not unduly spread … The plant accommodates readily to any forlorn waste land' (Mueller 1885: 209). It was cultivated in the Botanic Garden in the 1850s and 1860s (Mueller 1858b, Maroske pers. com.).

So were various apparently not-yet-naturalised species of *Rubus*, including several types of blackberry. The nine species recorded in the Botanic Garden in 1858 include *Rubus fruticosus*, the ordinary Bramble or Blackberry-bush (Mueller 1858b: 25). The 'British Blackberry, which proves to be remarkably prolific,' was among the numerous plants distributed to public institutions in 1861 (Mueller 1862: 6). In 1860 Mueller (1861: 5) welcomed the addition of the Canadian Blackberry *Rubus Canadensis* to the Botanic Garden and 'scattered the seeds of the large-fruited Canada blackberry along the alpine springs' on the Baw Baw plateau, later learning that 'this delicious fruit is established on the rivulets of that mountain' (Mueller 1871c: 38). In 1870 he told his audience 'Disseminate the Strawberries of the countries of our childhood, naturalise the Blackberry of northern forest moors' (Mueller 1871b: 72). In the mid-1890s *Rubus fruticosus* was not one of Victoria's over 200 acknowledged naturalised plants (Anon 1893), and Mueller continued to claim that it 'deserves to be naturalised on the rivulets of any ranges' in his *Select extra-tropical plants* (1895).

As the number of, and information about, desirable species increased the size of successive editions of Mueller's *Select extra-tropical plants*, so too did the small number of warnings about potential weeds. Warnings for ten of Mueller's (1888) naturalized species described in the 9th edition of *Select extra-tropical plants* (1895), include that Tall Meadow-oatgrass *Avena elatior* 'becomes easily irrepressible on account of its wide-creeping roots'; Wild Oats *Avena fatua* is 'hard to exterminate in grain-fields, where it sometimes proves quite troublesome'; Penny-royal *Mentha Pulegium* is 'To be avoided on pastures, as not readily repressed'; and Gorse or Furze *Ulex Europaeus* is 'Too apt to stray as a hedge plant'. Entries for 26 species in the 9th edition include some indication that the plant was a potential weed (Maroske 2005: Appendix U). Balancing the usefulness of plants with their possible weediness was not easy.

In retrospect

In an era when acclimatisation was an extremely popular exercise in what today might be called biological globalisation, Mueller and other well-intentioned Europeans introduced into Victoria all sorts of useful plants and animals from climatically similar parts of the world.

With the wisdom of hindsight we may smile dismissively at those responsible for such unsuitable past introductions as the fox, sparrow, Capeweed and blackberry, which we know have become invasive weeds and pests. Many such introductions have been environmentally disastrous. But, with ideas and technologies unavailable to ecologically-unaware 19th century acclimatisers, we should be careful of slick condemnations of actions and aspirations of so long ago.

No-one today would want to introduce something like the Bumble Bee. Or would they?

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Invasive plant pathogenic fungi in native Victorian ecosystems

James H Cunnington

Primary Industries Research Victoria (PIRVic), Department of Primary Industries, Knoxfield Centre, Private Bag 15, Ferntree Gully Delivery Centre, Victoria 3156. Email: james.cunnington@dpi.vic.gov.au

Abstract

Despite the introduction of hundreds of species of plant pathogenic fungi into Victoria over the last 200 years, *Phytophthora cinnamomi* is the only introduced fungus to have caused significant disease in native ecosystems. Of native plant pathogenic fungi, *Chalara australis* affecting Myrtle Beech is probably causing the most disease. Of fungi not yet present in Australia, Guava Rust *Puccinia psidii* and Sudden Oak Death *Phytophthora ramorum* are seen as the most significant potential diseases of native plants, while the Australian daisy rust *Puccinia lagenophorae* is a surprising invasive pathogen in Europe and North America. (*The Victorian Naturalist* **124** (1), 2007, 79-83).

Introduction

Of the more than 100 000 described species of fungi, approximately 10 000 can cause diseases in plants (Agrios 1997). Most plant species are affected by at least several different species of fungi, which are so well adapted to their hosts that they are unable to survive on any other material, but most of these do not cause significant disease in the plant (Alexopoulos *et al.* 1996). Disease can occur in all parts of the plant, although the roots and leaves are the most commonly affected. Root diseases can be quite striking as the infected plants are often unable to take up water, resulting in a complete collapse of the plant (if it is herbaceous), or rapid dieback of the leaves (if the plant is woody). Foliar diseases are easier to diagnose as the fungi usually produce discrete leaf lesions where they produce microscopic spores that are dispersed by wind and rain. Most plant pathogenic fungi, particularly those that cause foliar disease, are quite host specific, i.e. they only infect a single species of plant, or its close evolutionary relatives (Agrios 1997). There are fewer root pathogenic fungi, but these often affect a much wider range of plants.

There is a balance between plants and their pathogens in their natural environments. If a fungus killed an entire plant population, then the fungal population would also die out, as it would not have a host plant to live on. Eucalypts, for example, are affected by a very large number of fungal species (Keane *et al.* 2000), but these rarely cause serious disease in their native habitats. In plantations some of these can be serious pathogens. This is generally true for all plants that are brought into cultivation. As the crops become more genetically uniform and are grown repeatedly in the same soils, the balance between host and pathogen shifts to a point where a pathogen can become extremely aggressive and can destroy a crop (Agrios 1997).

Another way in which a pathogenic fungus can become very destructive is by introducing it to a new environment. The pathogen can jump onto new plant species and quickly cause significant disease or death. It is in these situations that the pathogen becomes truly invasive (Anagnostakis 1987). Luckily, there are not many serious cases of this happening, especially in Australia, but there are several species of plant pathogenic fungi expected to become serious invasive pathogens were they to be introduced into Australia. This paper will briefly discuss the two exotic species that are likely to become extremely invasive if they are introduced to Victoria. A rare example of an Australian fungus that has become invasive in Europe and North America will also be discussed. But first we will look at a North American example of a very serious invasive plant pathogenic fungus, and then two most important invasives in Victoria; one of which has been introduced, while the other is probably native.

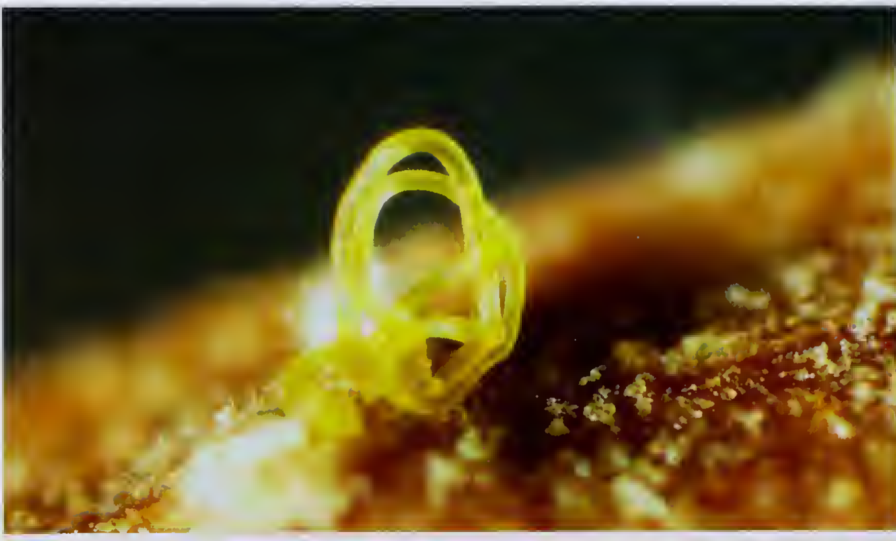

Fig. 1. *Cryphonectria parasitica* spores oozing from an infected chestnut stem. AQIS post entry quarantine station, Knoxfield, 2001. Photograph by Robin Eichner.

Fig. 2. Section through rust pustule of *Puccinia lagenophorae* showing two-celled teliospores. Specimen on *Lagenophora stipitata* from Daniel McAlpine collection, Kiewa Valley, 1902. Scale bar equals 40 µm.

Chestnut Blight in North America

The damage done by Chestnut Blight in North America can be used to appreciate the disastrous effects that a plant pathogenic fungus can have when introduced into a new geographical area. In 1905, American Chestnut *Castanea dentata* trees outside the New York Zoological Garden were reported to be dying (Anagnostakis 1987). Symptoms included bark cankers (lesions) and wilting of distal foliage. The causal agent was identified as the fungus *Cryphonectria parasitica* (an ascomycete). Native to Asia, *C. parasitica* is a minor pathogen of Japanese and Chinese

Chestnuts, *Castanea crenata* and *Castanea mollissima* respectively, but an extremely aggressive pathogen of American Chestnut. Once it arrived in North America, presumably on plants imported from Asia, it spread at a rate of about 37 km per year. The fungal spores are transported on the surfaces of animals and through rain splash. By the mid 1950s it was estimated that about 3.6 million hectares of American Chestnut trees were dead or dying. These trees were once a major component of the hardwood forests of the eastern United States, but now exist only as stems and stumps that continually re-shoot, only to become infected. If Chestnut Blight were to reach Australia it would destroy our, admittedly small, Chestnut industry. In 2001, Chestnut plants from Spain were about to be released from quarantine facilities in Victoria, when small lesions were found on the stems on one of the plants. Microscopic examination and fungal culturing revealed that it was infected with Chestnut Blight (Fig. 1). The plant appeared healthy during the two years it had spent in quarantine (Cunnington and Pascoe 2003).

The Cinnamon Fungus

In Australia the most invasive plant pathogenic fungus is the Cinnamon Fungus *Phytophthora cinnamomi* (an oomycete). Originally described from Cinnamon in the mountains of tropical Western Sumatra, *P. cinnamomi* needs little introduction to Australians, so will be mentioned here briefly. In Victoria it is the sclerophyll forests that are most affected by Phytophthora dieback (Weste 1974). Typically, susceptible trees and shrubs die back, to be replaced by relatively resistant grasses and sedges. Those plants most susceptible include species of *Xanthorrhoea*, Epacrid-aceae, *Acacia*, Myrtaceae, Fabaceae and Proteaceae. The impact of *P. cinnamomi* is so significant that it was listed as a 'Key Threatening Process' in the Common-wealth Environmental Protection and Biodiversity Conservation Act 1999. Hardham (2005) presents a recent review of *P. cinnamomi*.

Myrtle Wilt in Victoria and Tasmania

Myrtle Beech *Nothofagus cunninghamii* is a dominant tree in cool temperate rainforests in Victoria and Tasmania. The disease known as Myrtle Wilt was first reported in 1973 in north-western Tasmania, where areas of Myrtle Beech were noticed to be dying back. The causal agent, *Chalara australis* (anamorphic fungus) was not described until 1989 (Kile and Walker 1987). It is thought to be indigenous to south-eastern Australia. Myrtle Wilt has been found throughout cool temperate rainforests in Tasmania, and in the Otway Ranges, Central Highlands and Strzelecki Ranges in central and southern Victoria (Cameron and Turner 1996). The fungus is spread by airborne and waterborne spores that infect through wounds in the outer bark. It may spread from tree to tree via root contact or grafts. Death occurs six months to three years after infection. There is still some uncertainty regarding the natural status of Myrtle Wilt, given that it occurs in both disturbed and undisturbed sites, and that it has only reached epidemic levels in the past 30 years. If *C. australis* is truly an indigenous fungus, it is unusual that it has evolved to become an aggressive pathogen of its only host.

Exotic pathogens

The two plant pathogenic fungi that do not yet occur in Australia and are most likely to cause serious disease to native plants in Victoria are Guava Rust *Puccinia psidii* and Sudden Oak Death *Phytophthora ramorum* . *Puccinia psidii* (a basidiomycete) is a rust fungus native to South America. It infects leaves and stems, forming yellow spore-filled pustules. Infected leaves shrivel, and in heavily affected trees, severe defoliation can occur. The fungus occurs naturally on native South American plants in the subfamily Myrtoideae of the Myrtaceae, but also infects Australasian plants in the subfamily Leptospermoideae such as *Eucalyp-tus*, *Melaleuca* and *Callistemon* (Simpson *et al.* 2006). Its distribution appears to be spreading from tropical South America into more temperate regions in Central America, where it occurs as far north as Florida. In 2005 *P. psidii* was found in Hawaii on *Psidium*, *Eugenia* and *Metrosideros*. It is probably the most serious threat to native ecosystems in Australia.

Phytophthora ramorum (an oomycete) was described from Europe in 2001 where it was killing *Viburnum* and *Rhododendron*

(Werres *et al.* 2001). At that time the disease was known as 'Ramorum Dieback', but the fungus reached North America, where in California, it is currently killing very large numbers of oaks. This has led to a new common name for the disease, 'Sudden Oak Death'. *Phytophthora ramorum* is now known to affect over 100 species of plants from 30 families. Depending on the plant, the fungus can cause lethal cankers, shoot blights or leaf blights. It produces spores that are spread by wind and rain. The origin of *Phytophthora ramorum* remains unknown. The European and North American forms appear to be distinct, and may warrant separate subspecies. Both forms were probably recently introduced into their respective continents. Presumably they have arrived on plants, or plant products, from other parts of the world. Asia is often suggested as its origin, as large numbers of *Rhododendron* species are affected by *P. ramorum*, and the centre of diversity for *Rhododendron* is in Asia. The effect this fungus could have on native Australian ecosystems is also unknown given its wide host range and unpredictable pathogenicity.

Puccinia lagenophorae on composites

In the early 1960s a new rust fungus was reported causing leaf lesions on Groundsel *Senecio vulgaris* in Britain, France and Switzerland (Wilson *et al.* 1965). Its origin was unknown, and it was described as the new species *Puccinia terrieriana*. By 1965 it was very widespread in Britain and cross-infectivity studies using its air-borne spores revealed that it could infect other composites including Cineraria *Senecio cruentus*, English Daisy *Bellis perennis* and Calendula *Calendula officinalis*. A comprehensive examination of similar rust fungi revealed that it was not a new species, but rather the Australian native fungus, *Puccinia lagenophorae* (Wilson *et al.* 1965). Described in 1884, *P. lagenophorae* (Figure 2) infects several genera of Australian Asteraceae, including *Lagenophora*, *Calotis* and *Podotheca* (McAlpine 1906; herbarium VPRI and DAR records). Sixty species of composites are now known to be susceptible. The fungus has since moved to North America (Scholler and Koike 2001), where it has created some concern over the effect it may have on the 100 or so native species of *Senecio* (Littlefield *et al.* 2005). Although it does not cause serious disease in Europe and North America, *P. lageno-phòrae* is a good, but very rare, example of a plant pathogenic Australian fungus that is invasive in other parts of the world.

Final remarks

Over 200 species of plant pathogenic fungi have been introduced into Victoria in the last 150 years (Cunnington 2003). But, almost all of these have since infected only the plant species they were introduced with. Even those few introduced fungi that affect a wide range of introduced cultivated plants have not moved into native systems. Only *P. cinnamomi* has become a truly invasive plant pathogen in Victoria, yet the damage caused by this single invasive organism has been devastating. With the increasing movement of agricultural products around the world, quarantine legislation and inspection regulations continue to improve (Palm 1999). But even in Australia, where quarantine regulators are heavily funded, several new plant pathogenic fungi become established each year. We can probably consider ourselves fortunate that more plant pathogenic fungi have not become invasive in our native ecosystems.

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Contingency planning and prioritising pest plants

John Weiss

Department of Primary Industries
PO Box 48, Frankston, Victoria 3199. Email: John.Weiss@dpi.vic.gov.au

Weed control is an emotive issue and all land managers have to deal with it, often with limited funds. Land managers, however, are usually motivated to prioritise control of weeds having an obvious impact on their use of the land, for example those that are already well established and abundant. Recently, an increasing focus has been given to preventing weed spread early in the invasion process, that is, by attempting to eradicate particular species long before they expand and become widespread. Land managers need to identify the present and future priority weeds so that resources can be focused on them. This paper describes a generic process or contingency plan to assist in developing either local, regional or state plans to identify and act upon new and emerging pest plants. (*The Victorian Naturalist*, **124** (2), 2007, 83-86)

Introduction

Preventing the naturalisation of potentially invasive species is accepted as the first and most cost-effective option for dealing with biological invasions (Wittenberg and Cock 2001). Moreover, economic modelling suggests that preventing the spread of new pests can generate a benefit-cost ratio of up to 38:1, far exceeding most other forms of government investment (AEC group 2002).

Currently, it is estimated that at least 27 009 non-native plant species have been imported into Australia (Virtue *et al.* 2004). While it is difficult to predict how many of these will become invasive, nearly 8000 have documented histories as invasive species somewhere in the world and over 3000 of these already have naturalised somewhere in Australia (Randall 2006). It is possible that tomorrow's weeds, potentially over 4900 species, are being sold as garden plants right now.

Recent (1970 – 1995) plant introductions into Victoria

A total of 135 new vascular plant species were recorded as introduced into Victoria between 1970 and 1995. The number naturalising per year is shown in Fig. 1 and a regression indicates that the rate of new introductions is increasing, with the present average of 7.3 new plants establishing per year with an annual increase of 0.25 plants each year. Predominantly these new plants have originated from South Africa and Europe, and have been introduced deliberately as ornamental plants. The most common new invaders into Victoria are from the families Iridaceae and Poaceae in the Monocots; Salicaceae, Fabaceae, Asteraceae and Malaceae in the Dicots; and Pinaceae in the Conifer group (Groves and Hosking 1997).

Fig. 1. Number of new plant species naturalised in Victoria, 1970-1995, and linear regression (dotted line) indicating the rate of naturalisations.

The procedures presently being implemented by AQIS hopefully will prevent the introduction and release of many new weeds in Australia and Victoria. However, new weed problems would still arise in the future from several sources, including;

- invasive plants that continue to penetrate current or improved protocols for the introduction and release of potential weeds (e.g. plants may be considered benign but become weedy nevertheless);
- invasive plants that are introduced accidentally (e.g. as contaminants of imported seed);
- invasive plants already in Australia that assume major significance as weeds due to changes in environmental conditions (e.g. flood or fire) or other factors (e.g. climate change); and
- translocated native species.

Contingency plan

An early warning and contingency plan needs to have many separate systems with well defined protocols and procedures as well as defined roles and responsibilities of the key players. The strategy should include:

- a system to highlight new or potential weeds, which may need action;
- a system to identify;
- a system to assess risk;
- a notification system;
- a process to ensure a plan of action is developed;
- a process to implement and review the plan.

Waterhouse and Corlett (1996) indicated a similar procedure. Whenever a new (escaping or naturalised) alien species is recorded by any of the State herbaria:

1. Convey the details promptly to the appropriate 'designated authority' (e.g. Department of Natural Resources or Department of Agriculture).
2. Conduct a literature review to determine whether the species has been documented as a weed elsewhere.
3. Investigate the known native and exotic distributions and predict the potential Australian distribution.
4. Perform a weed risk analysis to determine whether it is likely to be a weed of any significance.
5. Recommend and implement actions as necessary. This may range from maintaining a 'watching brief' on the weed's distribution and invasiveness through localised control efforts to a full-scale eradication program.

6. Notify interstate 'designated authorities' of all new weeds, and keep them informed throughout the assessment process.

The process should not be halted at Step 2 if the literature review fails to reveal previous documentation as a weed, otherwise invasive species such as *Praxelis clematidea* will continue to be overlooked.

The Victorian Departments of Sustainability and Environment (DSE) and Primary Industries (DPI) instigated a Weed Alert and Rapid Response Plan in 2005 that implements a surveillance and response plan for potential new and emerging weeds in Victoria (DPI 2005).

Early Detection

Procedures are necessary to ensure that any new weeds are detected as early as possible. Early detection requires community awareness coupled with strategic monitoring; collections are encouraged as relatively few people collect weedy species and submit them.

An effective awareness program would lead land managers and users to recognise how important it is to call attention to any new plants appearing in their locality. The need for an awareness program is recognised in the Australian National Weeds Strategy (1999).

As distinguishing between indigenous and introduced flora is difficult, monitoring is required in native vegetation. Such surveys should determine hazard site selection or target areas that are prone to invasion (e.g. disturbed sites, roadsides and waterways), and possibly remote reserves where weed invasions could otherwise go undetected for a long time.

As predicting problematic plants is difficult, all introduced plants in native vegetation should be subject to field surveys, particularly with the anticipated change in weed distribution and impact associated with global warming forecasts. DSE and DPI are not sufficiently funded to routinely survey introduced species, although the need is recognised.

Identification and Reporting

Detection of potential problems must be supported by a readily accessible identification and reporting mechanism. The Australian National Weeds Strategy proposes that formal procedures should be developed with the following purposes:

1. All interested individuals will know where plants new to a particular area can be sent for identification.
2. Potential weeds submitted by individuals will be determined to be either:
   - plants previously recorded in the particular state or Territory or region/catchment from where they were submitted, or
   - plants not previously recorded in the particular State or Territory or region/catchment but recorded elsewhere in Australia, or
   - plants not previously recorded in Australia.
3. Agencies to which such plants are sent (National and State herbaria and government agencies with botanical expertise) will report plants new to an area to relevant weed control authorities.
4. Weed control authorities can rapidly assess the weed potential and significance of the new plant and make an appropriate response.

Plant identification and reporting mechanisms should be well coordinated across Australia. A compatible protocol should be implemented in Victoria, however the National Herbarium of Victoria is not currently funded specifically to collect or describe introduced species.

Assessment

The national post-border weed risk management protocol (Anon 2006) has been published recently to foster the use, standardisation and further development of decision support systems for prioritising weed species for management at different scales (Virtue and Panetta 2006)

With the limited amount of funding available to pest plant management, an assessment procedure has to be able to compare the relative importance of existing and of new and emerging weed problems. To accurately assess any plant requires using a combination of scientific data and expert knowledge. The problem is how to integrate human judgements with quantitative assessment techniques. The Analytical Hierarchy Process (AHP) is a Multiple Criteria Analysis technique which addresses this problem. Complex issues can be broken down into a set of related criteria. This systematic process is a 'divide and conquer' approach to problem solving. It is used

across many problem domains. By mapping out issues as a set of nested criteria, a decision hierarchy can be developed. The process also allows for relative importance or weight to be applied to each criterion and group. The DSS is a multi-layered system that rests on a database layer containing spatial data and tabular data from the departmental corporate database.

Victoria's Pest Plant Assessment project at DPI – Frankston has established a procedure to assess and prioritise any plant on its intrinsic abilities to invade suitable ecosystems and its present and potential impacts on social, environmental or agricultural land use. This procedure utilises the AHP of a Decision Support System.

The assessment procedure is split into three main parts: a scoring system which analyses a plant's intrinsic invasiveness characteristics, and production of the present distribution and potential distribution (utilising climate modelling programs). This distribution is then linked to a geospatial information database enabling impacts to be estimated on social, environmental or agricultural resource bases. A separate economic model is incorporated into the system which estimates the potential benefit in controlling these weeds on public or private land.

Thus any plant can be assessed for its relative importance compared to other weeds based on its intrinsic ability to invade (or rate of spread), its present and potential distribution and its Victorian social, economic and environmental impacts.

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One Hundred and One Years Ago

NOTES ON THE RUSTS OF AUSTRALIA

By D. M'Alpine, Government Vegetable Pathologist

(Excerpt from a paper read before the Field Naturalists Club of Victoria, 9th April 1906.)

Miscellaneous.- There are some interesting points in connection with certain species of rusts which are worthy of special mention. There is a rust found on the Marigold, which is a well-known imported plant, and it is only known at present in Australia, so that the question is raised whether the Marigold, since its introduction, has become subject to a native rust, or has the rust found upon it been overlooked in the Old World?

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Invasive terrestrial invertebrates in Victoria

Nick Collett[1], Greg Lefoe[2] and Alan L Yen[3]

[1]The University of Melbourne, School of Forest and Ecosystem Science,
123 Brown Street, Heidelberg, 3084. email: ncollett@unimelb.edu.au
[2]Primary Industries Research Victoria, Department of Primary Industries,
40 Ballarto Road, Frankston, Victoria 3199. email: greg.lefoe@dpi.vic.gov.au
[3]Primary Industries Research Victoria, Department of Primary Industries,
621 Burwood Highway, Knoxfield, Victoria 3056. email: alan.yen@dpi.vic.gov.au

Abstract

A high number of exotic invertebrate species has been accidentally or deliberately introduced into Victoria since European settlement. The effects of these introductions on native flora and fauna have ranged from benign through to devastating, depending upon the species in question and on the context of their introduction. Exotic species are generally easier to identify, and in the case of potential future invasive species identified through such processes as pest risk analysis combined with vigilant quarantine inspection processes, it is possible to anticipate and identify potential paths of entry to prevent incursions in the first instance. However, subsequently dealing with exotic pests that have successfully established and native invertebrate species that have become pests is a more complex scenario. This paper discusses some of the significant exotic invertebrates to have established in Victoria and their impacts on the environment, either beneficial, benign or adverse. Impacts of exotic invertebrates on amenity plantings and forests are examined, as well as issues covering invasive native invertebrates establishing outside of either their normal host or geographic range. Broad actions to prevent or limit the spread of exotic and native invasive invertebrates are also discussed.
(*The Victorian Naturalist*, 124 (2), 2007, 87-102)

Introduction

It is estimated that over 500 exotic species of insects and arachnids have become established in Australia since European settlement (Thomson *et al.* 1987). This figure included both accidental and deliberate introductions. No doubt, in the 20 years since this estimate was originally made, the number of exotic invertebrate species that has become established will have increased significantly.

This paper concerns 'invasive' invertebrates in Victoria. One definition of invasive invertebrates is 'a species that is not native to an ecosystem and whose introduction does or is likely to cause economic or environmental harm or harm to human health' (Chornesky *et al.* 2005). This definition links the concept of 'pest' to human interests.

The distinction between 'invasive' and 'pest' invertebrates is often blurred and ill-defined. Invasive species are often categorised as exotic species that have the ability to colonise rapidly and adapt to a particular environment, and in most cases, cause unwanted problems. Exotic species can be accidental or deliberate introductions but not all exotic species that are invasive become pests, and some have been deliberately introduced for primarily economic reasons such as the various biological control agents, earthworms and dung beetles. It is possible that a species introduced for economic purposes ultimately becomes a pest in its own right; cane toads, while not invertebrates, are an example of this.

The difficulty in defining invasive species is that not all invasive species are exotic. There are many examples of native species that naturally have large population boom and bust cycles and become pests, of which the Australian plague locust *Chortoicetes terminifera* (Walker) is a prime example. There are also native species that have been moved out of their natural range and become invasives, while some species have become invasives because of human mediated environmental change. Some exotic species have been deliberately introduced for beneficial reasons that may be perceived to have minimal environmental effects (biological control reasons) or there may be debate about these effects (e.g. European Honey Bees).

Hence the distinction between exotic, invasive and introduced species is rather arbitrary. This paper does not intend to

undertake a comprehensive review of all invasive invertebrates in Victoria. More thorough treatments can be found in New (1994). We do not include economic pests of introduced agricultural plants, nor do we consider the occasional outbreaks of the native Australian plague locust. We will primarily deal with invertebrates that may have significant detrimental effects on the environment but whose effects can be mitigated by actions undertaken by people. This includes introduced exotics, introduced native species, and forest insects because of their potential to expand their ranges due to changes in land use such as the expansion of the eucalypt plantation estate, agroforestry and shelter belts.

Environmental and amenity aspects of invasive invertebrates

The following is a brief resume of the better known invertebrates that have been introduced into Victoria. Some exotic invertebrates, such as several species of spiders (Yen 1995), have been accidentally introduced, but the effects of these are not known. Except for the European Honey Bee *Apis mellifera* Linnaeus, the list does not include species such as dung beetles, earthworms, parasitic wasps and other biocontrol agents, deliberately introduced for beneficial economic and environmental reasons. Whether these groups have had any adverse effects on the native fauna is not known.

Exotics

Slugs and snails

There are over 60 native slug and snail species in southeastern Australia, with 10 introduced slug and 12 introduced snail species also present (Daniell 1994). The main observable environmental effects are grazing on native plant species by introduced slugs and snails. Introduced slugs appear to be prevalent on native grasslands (where there are no known native species of slugs) with the snail species *Theba pisana* (Müller) also recorded in very high numbers in some coastal dune areas (Smith 1967). Introduced snails are not limited to the terrestrial environment, with the exotic snail *Potamopyrgus antipodarum* (Gray) having colonised some lakes in Victoria (Schreiber *et al.* 1998).

Portuguese Millipedes

The Portuguese Millipede *Ommatoiulus moreletii* (Lucas) (Diplopoda: Julidae) was first recorded in Australia at Port Lincoln, South Australia, in 1953 (Baker 1985). It is now widespread in south-eastern Australia, including Victoria, where it can reach very high densities (Baker 1985). Portuguese Millipedes are attracted to light, and become a nuisance when they invade homes. They are particularly active in autumn when most problems occur. Portuguese Millipedes have invaded a range of habitats in Australia including *Eucalyptus* woodlands, grasslands, and domestic gardens. Baker (1985) reported that the highest densities occur in newly invaded areas, with populations subsequently declining as the invasion front moves on. Explanations for this decline include depletion of resources such as food, or the impact of natural enemies as native predators adapt to a new prey source. There is, as yet, no evidence that Portuguese Millipedes impact directly on native millipedes although there have been only limited studies of interactions (Baker 1985; Griffin and Bull 1995). Baker (1985) suggested Portuguese Millipedes may occupy a previously vacant detritivore niche in Australia, however, further research on the potential impacts of Portuguese millipedes in natural ecosystems is needed.

European Wasp Vespula germanica, *English Wasp* Vespula vulgaris

The European Wasp *Vespula germanica* (F.) (Hymenoptera: Vespidae) is native to Europe, North Africa and temperate Asia, but has subsequently spread to North America, New Zealand, South Africa, South America and Australia (Spradbery and Maywald 1992). The English Wasp *V. vulgaris* (L.) (Hymenoptera: Vespidae) is closely related to the European Wasp, and in Australia has established in Victoria and Tasmania (Lefoe and Ward 2001, Matthews *et al.* 2000). Within Victoria and Tasmania the range of English Wasps is believed to be more restricted than that of European Wasps, although mis-identification is probably common where their ranges overlap. European Wasps are generally considered the more serious pest in

Australia because of their abundance and widespread distribution.

The English Wasp was first discovered in Australia at Malvern, Victoria, in 1958 and while the initial infestation was destroyed, more were found in 1960. Despite attempted eradication, English Wasps continued to spread in an easterly direction, reaching the Dandenong Ranges in the early 1970s, and West Gippsland by the late 1970s. English Wasps are now also present in southeastern Tasmania, including Hobart, where they are thought to have arrived as recently as 1995 (Bashford 2001).

European Wasps possibly arrived in Australia from New Zealand, where they had initially been accidentally introduced and established (Spradbery and Maywald 1992). The first record of European Wasps in Australia was in 1954 at Sydney, where hibernating queens were discovered in a timber consignment from New Zealand (Chadwick and Nikitin 1969). The first nests were discovered in 1959 in Hobart, Tasmania, and later in New South Wales (1975), Western Australia and Victoria (1977) and South Australia (1978) (Spradbery and Maywald 1992). European Wasps have continued to spread across south and south-eastern Australia where they have quickly become widespread in Tasmania, Victoria and New South Wales (Spradbery and Maywald 1992). Crosland (1991) estimated unaided queen dispersal at only 730-815 metres per year. European Wasps, however, can spread more rapidly through accidental human transportation of hibernating queens (Crosland 1991). In South Australia, European Wasps remain a predominantly urban problem, although their numbers have increased steadily. While repeated introductions have occurred in Western Australia, with a large outbreak recorded in Perth in 1990, European Wasps are not yet considered to have successfully established in that state (Widmer and van Schagen 1995). In Queensland, reports of European Wasps occurred during 1988 and 1991, and the first nest was found in 1992 (Spradbery and Maywald 1992).

European and English Wasps impact on a number of different sectors in the community. In years of high abundance European and English Wasps can affect some agricultural industries such as Honey Bees and soft-fruit industries, especially grape growing and wine making operations. European Wasps can also cause serious injury, with hospitalisations due to stings increasing in Australia (Levick *et al.* 1997). European and English Wasps are particularly aggressive when their nest is threatened, and accidental disturbance of wasp nests poses a considerable threat to humans and other animals. In urban areas, the major concern is wasp stings, although disruption to outdoor activities and the cost of control add to the impact of wasps.

Most information on the deleterious impacts of wasps in natural ecosystems derives from studies conducted in New Zealand (Beggs and Wilson 1991, Harris and Oliver 1993, Beggs and Rees 1999). In natural ecosystems, wasps prey on native invertebrates, compete with native animals for food, disrupt natural ecosystem processes, and can pose a health risk to Parks staff and visitors. However there is very little detailed information on the impacts of wasps in Australian ecosystems. In Tasmania, European Wasps prey on the threatened Ptunarra Xenica *Oreixenica ptunarra* (M Driessen pers. comm. 2001). Bashford (2001) also reported that the number of calliphorid flies caught in Malaise traps at Warra, Tasmania, declined as the number of *Vespula* spp. increased. Continued studies at the site may determine whether introduced *Vespula* wasps have any long term impact on populations of calliphorid flies and other prey species.

The European Honey Bee, Apis mellifera

The European Honey Bee, *Apis mellifera*, has been in Australia for over 100 years. It has been an important part of the economy in the provision of honey, but there has been considerable debate about whether it has been detrimental to native bees and other insects, native birds and native plants. Paton (1996) concluded that it was difficult to generalise about the effects of *A. mellifera*, and in a special issue of *The Victorian Naturalist*, New (1997), Schwarz and Hurst (1997), Manning (1997), and Paton (1997) presented different perspectives on the issue. Paini and Roberts (2005) provided some preliminary evi-

dence on *A. mellifera* affecting native bees, but Paini (2004) stated that possibly any adverse effects are historical. In fact, Yates *et al.* (2005) give one example in an urban park where feral Honey Bees may be the major pollinator of some native plant species. To complicate the matter further, there could be potential flow-on effects if the Honey Bee Mite *Varroa destructor* (Anderson & Trueman) gets into Australia (Cunningham *et al.* 2002).

Tramp ants

Environmental conditions in Australia have resulted in the evolution of a very rich and diverse ant fauna that undertakes a range of important ecological functions (Andersen 1983). A significant threat therefore to the Australian environment is the establishment of exotic ant species. Several species have been identified as invasive and have colonised different parts of the world primarily by hitch-hiking on freight transport. These ants, collectively named tramp ants, originate mainly in Central and South America, Africa or South Asia (McGlynn 1999), and have colonised both urban and natural habitats. Australia has been colonised by eleven tramp ant species: the ghost ant *Tapinoma melanocephalum* (Fabricius), the white-footed ant *Technomyrmex albipes* (F. Smith), the red imported Fire Ant *Solenopsis invicta* (Buren), the Crazy Ant *Paratrechina longicornis* (Latreille), the Yellow Crazy Ant *Anoplolepis gracilipes* (Fr. Smith), the African Big-headed Ant *Pheidole megacephala* (Fabricius), the Argentine Ant *Linepithema humile* (Mayr), the Singapore Ant *Monomorium destructor* (Jerdon), the Pharoah Ant *Monomorium pharaonis* (Linnaeus), the Tropical Fire Ant *Solenopsis geminata* (Fabricius) and the Little Fire Ant *Wasmannia auropunctata* (Roger) (Commonwealth of Australia 2006). Whereas specimens of the Pharaoh Ant were collected in St Kilda in 1938, and the Singapore Ant in Camberwell (1939) and Myrtleford (1940), these two species are primarily tropical and these records probably reflect more transient than established populations (John Wainer, pers. comm. 2006). The African Big-headed Ant was found in Melbourne by Clark (1941) and more recently by Wainer (pers. comm. 2006). The red imported Fire Ant entered Victoria in 2001 via potted palm trees originating from Queensland, where it is under eradication, and in soil on a shipping container from the USA. Both these Victorian incursions were subsequently eradicated (John Wainer, pers. comm. 2006).

The major tramp ant species in Victoria is the Argentine Ant. This species was first found in Balwyn in 1939 (Clark 1941), and it is thought to have spread from this initial colony to colonise Tasmania, New South Wales, the ACT and Western Australia. It is primarily a pest of urban environments where it can nest in suitable cavities outside homes from which they can establish large foraging trails into houses to seek food and water. Colonies can range in size from a dozen to many thousands and they can establish satellite nests that are highly mobile. However, their pest status spreads beyond the urban environment and they have an impact in orchards by protecting honeydew producing insects such as aphids and scales against their natural predators and parasitoids. There are reports of Argentine Ants reducing the abundances of native ants in California (Holway 1998), Hawaii (Cole *et al.* 1992), South Africa (Bond and Slingsby 1984) and Japan (Touyama *et al.* 2003). Recently, Rowles and O'Dowd (2007) demonstrated that the Argentine Ant displaced native ant species from baits in coastal scrub vegetation on the Mornington Peninsula. This displacement has the potential to alter plant community composition because some of the displaced native ant species (species of *Pheidole* and *Rhytidoponera*) are important dispersal agents and predators of seeds.

Elm Bark Beetle, Elm Leafhopper, Elm Leaf Beetle

In Australia the exotic elm tree *Ulmus* spp. has been widely planted in urban landscapes, especially in Victoria. The largely pest-free status of elms in Australia changed in 1974 when the smaller European Elm Bark Beetle, *Scolytus multistriatus* (Marsham) (Coleoptera: Curculionidae), was discovered in Melbourne. While its mode of entry into Australia has not been precisely determined, it possibly occurred through the

Port of Melbourne, using dunnage as its vector. Later surveys subsequently found the smaller European Elm Bark Beetle to be well established in Victoria (Neumann and Minko 1985) and it has since spread into New South Wales, the Australian Capital Territory and South Australia (Neumann 1987). The smaller European Elm Bark Beetle, while widespread, is usually considered a minor pest in the absence of the Dutch elm disease (DED) pathogen. However, as a known vector of the causal agents of DED, *Ophiostoma ulmi* (Buisman) and *O. novo-ulmi* Brazier, the beetle has the potential to rapidly spread these pathogens should they be introduced into Australia.

In 1986 the Elm Leafhopper, *Ribautiana ulmi* Linnaeus (Hemiptera: Cicadellidae) was observed on elms around Melbourne although its mode of entry is not known. This species of leafhopper causes cosmetic damage or 'speckling' of leaves by damaging leaf mesophyll cells. There is very little known of its long-term effects on tree health and it is usually considered a minor pest (Missen *et al.* 1991).

The Elm Leaf Beetle, *Pyrrhalta luteola* Müller (Coleoptera: Chrysomelidae), a serious pest of European elms, was first discovered on the Mornington Peninsula, Victoria, in 1989 (Kwong and Field 1994). While its mode of introduction is again unknown, it was well established before its initial discovery. The elm leaf beetle is now defoliating elms in metropolitan Melbourne and much of regional Victoria (Lefoe 1999). Where infestations occur, control measures are required to be implemented immediately to prevent serious defoliation damage occurring. If not adequately controlled, Elm Leaf Beetle is likely to shorten the lives of elms in Australia and can make them more prone to attack from the smaller European Elm Bark Beetle.

Native species

Moreton Bay Fig psyllid

The Moreton Bay Fig *Ficus macrophylla* is native to New South Wales and Queensland, being widespread in coastal scrub and coastal rainforest (Floyd 1989). It is a large tree, up to 50 metres high, and has been planted widely in parks and gardens in Victoria. A native psyllid *Mycopsylla fici* (Tryon) (Hemiptera: Homotomidae) causes significant damage to Moreton Bay Figs in Victoria (Honan and McArthur 1998). Feeding by immature psyllids causes localised leaf necrosis and early leaf fall. Fallen leaves containing sticky lerps are also a nuisance to pedestrians and potentially hazardous when they stick to shoes on wet paths. For these reasons chemical control of psyllids is sometimes necessary, although the size of the trees, and the protection afforded by the sticky lerps has made control difficult. Recent studies (Honan and McArthur 1998; Lefoe 2005) have provided useful information to enable tree managers in Victoria to monitor psyllid populations and determine whether control is necessary. A native parasitoid *Psyllaephagus* sp. (Hymenoptera: Encyrtidae) is present in Melbourne (Honan and McArthur 1998), further highlighting the need to conduct chemical applications prudently. Although both *M. fici* and *Psyllaephagus* sp. are common in central Melbourne, their statewide distribution is not known.

Forestry aspect of invasive invertebrates

Exotic invertebrates

Quarantine provides the first line of defence against the unwanted introduction into Australia of forestry-related insect pests, and their subsequent establishment in the plantation estate (Lawrence 1963; Department of Primary Industries and Energy 1996). This involves the careful inspection by trained observers of all wood products and related material capable as acting as a vector for forest insect pests, and the treatment or immediate destruction of any pests once found. Regular reviews are also conducted to allow for new products and pathways of entry that continually develop (Senate Standing Committee on Natural Resources 1979). Despite continual enforcement of strict quarantine measures at Australian ports, at least 46 species of exotic forestry-related insect pests have breeched quarantine barriers and established in Australia (Table 1).

An 'established forest insect pest' is defined as an exotic insect that has passed through a complete generation or lifecycle on or within a native or exotic tree

Table 1. Some exotic forest/forest product insect pests, or related organisms, known to have established in Australia (Department of Primary Industries and Energy 1996).

Order/family	Genus/species	Comments
Acarina (mites, ticks)		
Tetranychidae	*Oligonychus ununguis* (Jacobi) Spruce spider mite	Damage to foliage of *Pinus* spp. in Queensland (Wylie 1978)
Isoptera (termites, 'white ants')		
Kalotermitidae	*Cryptotermes brevis* (Walker) West Indian drywood termite	Damage to seasoned exotic and native softwoods and low-density hardwoods (Gay 1967) established in Queensland during 1930s and detected in NSW in 1946 (Heather 1971; Eldridge and Simpson 1987)
	C. cynocephalus Light	Damage to seasoned timber, probably introduced during 19th century (Wylie, DPI Qld, pers.comm.)
	C. domesticus (Haviland)	Damage to seasoned timbers, introduced in early 1950s (Yule and Watson 1976; Miller and Paton 1983)
	C. dudleyi Banks	Damage to seasoned timbers introduced during the 19th century (Wylie, DPI Qld, pers.comm.,)
Hemiptera (bugs)		
Adelgidae	*Pineus pini* (Macquart) Pine adelgid	Damage to foliage of *Pinus* spp. on marginal sites (Tanton and Alder 1977)
Aphidae	*Elatobium abietinum* (Walker) Spruce aphid	Damage to foliage of *Picea* spp. (Naumann 1993)
	Essigella californica (Essig) Monterey Pine aphid	Damage to foliage of *Pinus* spp. (Collett et al. 2000)
	Euceraphis betulae (Koch) European birch aphid	Damage to foliage of *Betula* spp. (Naumann 1993)
	Myzocallis castanicola Baker Oak aphid	Damage to foliage of *Quercus* spp. (Naumann 1993)
	Pemphigus bursarius (Linnaeus) Poplar gall aphid	Damage to foliage of *Populus* spp. (Naumann 1993)
Cicadellidae	*Ribautiana ulmi* (Linnaeus) Elm Leafhopper	Damage to foliage of *Ulmus* spp. (Neumann 1991)
Coleoptera (beetles)		
Anobiidae	*Anobium punctatum* (De Geer) Furniture beetle	Damage to seasoned softwoods (French 1968, 1970; CSIRO 1939)
	Ernobius mollis (Linnaeus) Pine bark anobiid	Damage to bark of softwood (Brimblecombe 1957)
Bostrichidae	*Dinoderus minutus* (Fabricius) Bamboo borer	Wylie and Yule (1977)
	Lyctus brunneus (Stephens) Powderpost beetle	Serious damage to seasoned sapwood of many eucalypts and brushwoods (Rosel 1969; Wylie and Yule 1977)
	L. discedens Blackburn Small powderpost beetle	As above
	Minthea rugicollis (Walker) Hairy powderpost beetle	Damage to seasoned sapwood (Wylie and Yule 1977)

Table 1 cont.

Order/family	Genus/species	Comments
Coleoptera (beetles)		
Bostrichidae	*Rhyzopertha dominica* (Fabricius) Lesser grain borer	Wylie and Yule (1977)
	Xylopsocus gibbicollis (Macleay) Common auger beetle	Wylie and Peters (1987)
	Xylothrips religiosus (Boisduval) Northern auger beetle	Wylie and Yule (1977)
Cerambycidae	*Aridaeus thoracicus* (Donovan) Tiger longicorn	Wylie and Peters (1987)
	Hylotrupes bajulus (Linnaeus) European house borer	Damage to seasoned softwood timber (Howick 1966)
Chrysomelidae	*Pyrrhalta luteola* (Müller) Elm Leaf Beetle	Damage to foliage of *Ulmus* spp. Established in Victoria in or before 1989 (Neumann 1991; Kwong and Field 1994)
Curculionidae		
Platypodinae	*Crossotarsus mniszechi* Chapuis	Ambrosia beetle; Wylie and Yule (1977)
	Diapus pusillimus Chapuis Walnut pinhole borer	As above
	D. quinquespinatus Chapuis	As above
	Platypus parallelus (Fabricius) Common ambrosia beetle	As above
Scolytinae[1]	*Eccoptopterus sexspinosus* (Motschulsky)	Wylie and Yule (1977)
	Hylastes ater (Paykull) Black pine bark beetle	Usually in inner bark of dead pine material, occasionally kills young seedlings on second rotation sites (Minko 1958; Neumann 1987)
	Hylurgus ligniperda (Fabricius) Goldenhaired bark beetle	As above
	Ips grandicollis (Eichhoff) Fivespined bark beetle	Mostly 'secondary', but occasionally a 'primary' tree killer of *Pinus* spp. Established since 1942 (Morgan 1967, Rimes 1959, Neumann and Morey 1984)
	Phloeosinus cupressi Hopkins Cypress bark beetle	Neumann (1987)
	Scolytus multistriatus (Marsham) Elm Bark Beetle	Established since 1974 in Victoria; carrier of Dutch Elm Disease (Rosel and French 1975; Neumann and Minko 1985)
	Xyleborus ferrugineus (Fabricius)	Established in Queensland before 1971 (J.King, DPI Qld, pers.comm.); has attacked green logs of Bunya pine in Queensland; also logs from fire-killed Pinus spp. (Wylie *et al.* 1996)
	X. fornucatus Eichhoff	Booth *et al.* (1990)
	X. indicus Eichhoff	Wylie and Yule (1977)

Table 1 cont.

Order/family	Genus/species	Comments
Coleoptera (beetles)		
	X. perforans (Wollaston) Island pinhole borer	As above
	X. saxeseni (Ratzeburg) Fruit-tree pinhole borer	Neumann and Minko (1985)
	X. similis Ferrari	Booth *et al.* (1990)
	X. solidus Eichhoff Thickset scolytid borer	Naumann (1993)
	X. torquatus Eichhoff	Wylie and Yule (1977)
Lepidoptera (butterflies, moths)		
Gracillariidae	*Phyllonorycter messaniella* (Zeller) Oak leafminer	Damage to foliage of *Quercus* spp. (Naumann 1993)
Hymenoptera (wasps ants bees, sawflies)		
Siricidae	*Sirex noctilio* Fabricius Sirex wasp	The most destructive tree-killing pest in plantations of *Pinus* spp. Established in Tasmania in 1950s and in Victoria in 1962 (Gilbert and Miller 1952; Irvine 1962; Neumann and Minko 1981)
Vespidae	*Vespula germanica* (Fabricius) European wasp	Important pest in operational and recreation forestry (Dept.Agric.Vic. 1983; Crosland 1991)
	V. vulgaris (Linnaeus) English wasp	Detected in Victoria in 1958; important pest in operational and recreation forestry (Dept.Agric.Vic. 1983)

[1] Sub-family Scolytinae is reported to contain 92 established species in Australia, of which 26 are considered exotic (Brimblecombe 1953).

species or originally uninfested imported or locally produced wood product. life-cycles however, can vary substantially between insect pest species resulting sometimes in variations of times when the insect pest entered Australia and when it was first detected. For example, the Asian Gypsy Moth *Lymantria dispar* (Linnaeus), a foliage feeder with a one year life-cycle is potentially more detectable in its early establishment phase than the European House Borer (*Hylotrupes bajulus* (Linnaeus)), a less visually apparent wood boring insect that has a life-cycle of between one and twenty years.

The frequency of exotic insect pest interceptions is generally linked to two factors, namely the countries/regions with which we conduct the major part of our trade and the pathway (mode of entry) by which the exotic pest gains entry. Studies by Wylie and Peters (1987) found that the majority of intercepted wood-boring insect taxa originated in Asia (46.1%) with the next largest group originating from the Australasia/Pacific region (30.4%), with Asia especially being our most significant trading region. However, care should be taken in the interpretation of such trends. For example, Australia conducts significant trade with North America and yet interceptions account for only 6.9% of total interceptions, indicative of potentially more strict quarantine procedures prior to goods being exported and the types of goods exported.

In examining the modes of entry by which insect pests enter Australia, studies have found that sawn timber and wooden crates account for 45% and 30% respec-

tively of all interceptions (Wylie and Peters 1987). Using such data is useful in directing sometimes scarce resources to monitor the most likely entry pathways for future insect pest incursions into Australia.

Impacts of forest insect pests
In terms of forestry, most invasive exotic invertebrates have impacted on exotic plantation species such as *Pinus radiata* D.Don although a few native insect species such as *Lichenaula* spp. (a defoliating moth species) have adapted to exotic tree species such as *P. radiata* and, on occasion, cause varying degrees of damage. One of the most significant insect pest species of *P. radiata* is Sirex Wood Wasp *Sirex noctilio* Fabricius, first recorded in Victoria in 1961 where it caused significant tree mortality before the introduction of various biocontrol and silvicultural control methods in the 1970s and 1980s. Sirex, through the introduction of phytotoxins, not only kills trees but also renders the timber subsequently useless for construction or pulping purposes. In the mid-1970s a severe outbreak of Sirex caused extensive tree mortality in the Delatite area of north-east Victoria (Neumann *et al.* 1987), while lesser outbreaks have been recorded in south-west Victoria near Rennick in the mid-1980s and around Shelley in north-east Victoria in the late 1990s.

A recently introduced aphid species the Monterey Pine aphid (*Essigella californica* (Essig)) first observed in north-east Victoria in the late 1990s has established throughout the pine estate where it has caused significant defoliation damage over a wide area. Symptoms of damage include mottled chlorosis of the older needles followed by premature needle shed with defoliation most predominate in the upper crown between March and July (Collett *et al.* 2000). However, defoliation of the lower crown can also be associated with very severe levels of aphid attack (Collett *et al.* 2000). Defoliation is predominantly observed in pine stands greater than 15 yrs of age. However, it has also been observed occurring in stands of all age classes (Collett *et al.* 2000). Such defoliation has been shown to result in substantial reductions in incremental growth and associated declines in timber yields (May 2004). Initial surveillance data have shown defoliation to be most pronounced in north-east Victoria and to a lesser extent in the Ballarat region, coinciding with regions where mean autumn daily temperatures of approximately 22° C predominate.

The Fivespined Bark Beetle *Ips grandicollis* (Eichhoff) and to a lesser extent the Golden-haired Bark Beetle *Hylurgus ligniperda* (Fabricius) and Black Pine Bark Beetle *Hylastes ater* (Paykull) generally attack young, newly established seedlings in plantations where sometimes widespread mortality is caused through lethal feeding attacks in the outer cambium layers of trees (Neumann and Morey 1984; Department of Conservation, Forests and Lands 1988). Attack is most predominant in summer months when the higher temperatures allow rapid increases in beetle populations in freshly felled green slash on logged sites, before damaging feeding and breeding attacks on adjacent young trees and seedlings. Damage by *Ips* is also caused to freshly felled logs stored on logging landings where feeding attacks allow the introduction of blue stain fungus *Diplodia pinea* (Desm.) into timber, rendering it subsequently useless for pulp paper production. Widespread *Ips* attacks on seedlings and young four-year-old Radiata pine trees have been documented in south west Victoria in the early 1980s with lesser attacks occurring around Myrtleford and Bright (Department of Conservation, Forests and Lands 1988).

While these examples are by no means comprehensive, they serve to show the variety of age classes attacked, the range of damage (i.e. defoliation and borer damage) caused and the spread of seasons and locations in which damage is caused. Some pests have an already long history within Victoria (i.e. Sirex), with comprehensive information available on their 'attack profiles'. However, some of the more recent introductions such as the Monterey Pine aphid require longer term research coupled with ongoing surveillance to develop pest profiles so as to assist in making more informed longer term management decisions.

Invasive native pest invertebrates
In terms of invasive native invertebrates within a forestry setting in Victoria, this

concept requires a more detailed definition of what situations we consider a native insect to be termed a 'pest' species. In native forests it is difficult to define adequately outbreaks of native invertebrate species such as the Red Gum psyllid *Cardiaspina retator* (Taylor), Gumleaf Skeletoniser *Uraba lugens* Walker and Spurlegged Phasmatid *Didymuria violescens* (Leach) as 'pest outbreaks'. Such 'outbreaks' are well documented in the literature throughout Victoria in the past 50-60 years (Neumann and Marks 1976; 1990; Neumann 1978; Collett 2001; Harris 1972; Elliott *et al.*1998) and it could be suggested that such outbreaks are cyclical and form part of the normal 'ebb and flow' of invertebrate activity within native forests. Only when these 'outbreaks' impact on economic activities such as harvesting and logging or on the aesthetics of forest areas with parks and reserves could we possibly consider them 'pest outbreaks' in the traditional sense. When examining the 'invasive' aspects of such outbreaks, there is no substantial documented evidence that any of these 'pest species' generally move beyond their expected geographic range when in outbreak mode to native forest areas outside this range. Only when these insect species are found within native plantations may it be reasonable therefore to treat them as 'invasive pest' species. An example of this scenario is *U. lugens* in north central Victoria, which has caused occasional defoliation to *E. camaldulensis* (Dehnh.) plantations (Collett pers. comm. 2006), with the original populations having originated within native red gum forests in the region. In these situations, the possibility of parallels being made with exotic insect incursions in exotic softwood plantations could be made, although the potential to control such outbreaks, especially using methods such as biological control, would be substantially diminished.

Of concern, however, is the potential for eucalypt plantations using tree species planted well out of their native range to 'draw in' native insect pest species, which in turn may divert either on to local native plant species or alternative native plantation species. The situation may also arise whereby the spread of these 'invasive' native pests may not be accompanied by their range of native biocontrol agents. Examples of this scenario include *E. grandis* (Hill) plantings at Mildura, which have drawn in populations of Autumn gum moth *Mnesampela privata* (Guenee) into the region (Bashford 1998).

Future threats posed by exotic pest incursions

The list of exotic insect pest species likely to cause considerable damage to the plantation industry in Victoria is potentially enormous. Until an exotic pest species has entered and established, there is no certain way to determine the exact threat it poses to both native and exotic plantation tree species. However, in order to plan for the eventuality of such exotic insect pest incursions occurring, rigorous interrogation of available information is conducted to determine the country of origin of potentially dangerous insect pests, including such information as their host tree species range, life-cycle and optimal environmental conditions for development both in their country of origin and Australia. This information is incorporated into pest profiles known as Pest Risk Assessments (PRAs) which can be specific to individual pest species or generically written to cover a range of insects posing a similar risk. A PRA includes all known available information on a pest species as well as contingency plans for dealing with an incursion and potential outbreak of the pest in Australia. The lists of potential pest species and associated PRAs varies constantly as new information is gathered, examined and updates provided accordingly.

While many insect pest species pose a considerable threat to plantations, a small subset has been selected as species with the greatest potential to establish and cause significant economic and environmental damage. This list is shown in Table 2 and was compiled by the Australian Quarantine and Inspection Service (AQIS) in consultation with state forestry authorities (Commonwealth of Australia 2001). Of the species listed, the majority are borer species with the potential to enter Australia cryptically within timber products, and consequently are sometimes difficult to assess fully and subsequently treat. Other pests such as the potentially highly

Table 2. Exotic forest/timber insect pest species yet to establish in Australia posing a potentially considerable threat to forest and amenity trees and timber in service (Commonwealth of Australia 2001).

Genus/species	Origin	Comments/Potential Impact
Isoptera (termites)		
Coptotermes formosanus Shiraki	China, Taiwan, Japan, Sri Lanka South Africa, USA (Hawaii)	Can severely damage timber in buildings. Very destructive.
Incisitermes minor (Hagen)	USA, Mexico, Canada	A serious pest of timber in service.
Coleoptera (beetles)		
Anoplophora glabripennis (Motschulsky)	Sth China, Korea, Japan USA (parts of)	Serious hardwood pest (eucalypts, pears, apples)
Arhopalus ferus (Fabricius)	UK, Europe, Russia, New Zealand	Pest of windthrown and fire damaged trees
Stromatium barbatum (Fabricius)	India, Sri Lanka, Burma, Mauritius Madagascar, Pakistan, Nepal	Pest of seasoned timber with large host range
Hylotrupes bajulus (Linnaeus)	Europe, Middle East, Africa, Asia, Sth America, USA, China	Highly destructive pest of seasoned softwood
Vanapa oberthuri (Pouillaude)	Papua New Guinea, Indonesia	Serious impact on native *Araucaria* species
Ips typographus (Linnaeus)	Europe, China, Japan, Korea Russia	Serious pest of spruce species
Dendroctonus ponderosae Hopkins	Canada, USA	Attack leads to introduction of wood decaying fungi
Heterobostrychus aequalis (Waterhouse)	Europe, India, Asia, Middle East, South Africa	Attacks exposed wood in houses, furniture and panelling.
Lepidoptera (moths, butterflies)		
Lymantria dispar (Linnaeus)	China, Eastern Russia, Korea, Japan, USA	Highly destructive defoliator of over 600 tree species
L. monachal (Linnaeus)	As above	Defoliator of numerous tree species (elms, oaks, conifers)
Orgyia thyellina Butler	China, Korea, Eastern Russia, Japan, Taiwan	Serious pest of exotic ornamental tree species
Hymenoptera (bees, wasps, ants)		
Camponotus pennsylvanicus (De Geer)	USA, Canada	Pest of seasoned timber in service
Urocerus gigas (Linnaeus)	Asia, Europe, Chile, USA, Canada, Russia	Can kill stressed trees (pines and other conifer species)

destructive Asian Gypsy Moth (Matsuki *et al.* 2000), while more visible as their egg masses are laid on object surfaces, can lay these egg masses on a variety of material (i.e. timber, metal, plastics, etc) and consequently, require more detailed examination in order to locate and treat.

The future: possible effects of invasive invertebrates on ecosystem function and solutions

The question that arises is whether in the long term some of the invasive species become naturalised or 'integrated' into the Australian fauna or whether they have a significant adverse effect on the structure

and functioning of Australian ecosystems. The Australian environment is unique in that a significant proportion of its invertebrate fauna is dependent upon the dominant *Eucalyptus* and *Acacia* flora (Majer *et al.* 1997). Many tens of thousands of plant-feeding insect species have co-evolved with their *Eucalyptus* or *Acacia* host plants, and there is a complex, but poorly understood, relationship that involves varying degrees of host plant specificity (from monophagous – feeding on only one host plant species, through to polyphagous), and the ability to utilise different host plant species in different locations (Fox and Morrow 1981). It is possible that colonisation of different host plant species by polyphagous species (either native or exotic) may result in the reduction of insect diversity associated with *Eucalyptus* and *Acacia*. The spread of some of these polyphagous species through the Australian environment may be aided by tree planting, agroforestry, and the spread of weedy native species. An example of the latter may be the spread of the weedy *Acacia baileyana* F. Muell. and *A. longifolia* (Andr.) Willd. through the bush and possibly the spread of a psyllid species *Acizzia uncatoides* (Ferris and Kylver) (Yen 2002). While herbivorous insects are important, the potential adverse effects of invasives may become more readily apparent with pollinators. Pollination of native plant species is another area that could be affected by invasive species. The potential effects of the European Honey Bee have already been discussed. Exotic predators such as the European Wasp may have inhibited pollination of native plants by their native pollinators (Bashford 2001; Hingston *et al.* 2004).

The Bumblebee *Bombus terrestris* Linneaus is another exotic species that has already been introduced into Tasmania, and there is current research on its effects upon the native flora and fauna (Hingston and McQuillan 1998; Hingston 2005, 2006; Hingston *et al.* 2006). An application to introduce the Bumblebee to the mainland for the pollination of glass house plants such as tomatoes was submitted under the Commonwealth *Environment Protection and Biodiversity Conservation Act* (1999), and is still under consideration. In Victoria, the introduction of bumblebees is listed as a potentially threatening process under the *Flora and Fauna Guarantee Act* (1988). This listing cited the potential for *B. terrestris* to (1) pollinate a suite of exotic plants that it pollinates in their countries of origin, resulting in the possible spread of more exotic weeds; (2) compete with native nectar feeding fauna; and (3) cause a possible decline in the seed production of native plant species.

It is difficult to outline uniform guidelines for both exotic and native invasive invertebrate species. Three broad general actions covering both groups may consist of:

1. Exclusion of future invasives (quarantine). This is clear, in principle, for exotic species, but more difficult for native species that are transported across Australia. Native species that become 'pests' can be species (a) that have been moved around with their native host plant; (b) that switch host plant species to colonise new native host plant species; and (c) that have colonised exotic plant species.

For exotic species, effort can be directed at their paths of entry and establishment. The paths of entry considered the most likely points of entry of pests into Victoria are through major seaport and harbour areas, overseas airports and international mail centres (Commonwealth of Australia 2006). International mail centres pose the least risk, firstly because the type of suitable host material (i.e. foliage, timber) is not imported through the centres in the necessary quantities likely to lead to an establishment, and secondly because of the thorough inspection regimes conducted at such locations. International airport arrivals pose a greater risk, as cargo flights have the capacity to bring in sufficient quantities of potential host material such as timber and plant products to allow an exotic establishment to occur. However, by far the greatest threat is posed by the entry of high volumes of cargo through major seaports. In recent times, additional emphasis has been placed on examination of high-risk vectors such as pallet wood and packing

crate timber, but despite the high levels of inspection, some movement of exotic pests outside of the port of entry is inevitable.

In addition to initial entry points, it is the experience of overseas countries (including New Zealand and the United States) that it is within a 5 km radius of such entry points that initial establishment of exotic pest species occurs. New Zealand studies have identified that 55% of new forest pest incursions were detected by formal port environs surveys, while 29% were detected during forest surveys (Gadgil 2000). In ports such as Melbourne, Geelong, Westernport and Portland within Victoria, urban areas are interspersed with parks, gardens and street trees, and/or large areas of native bush and planted shelterbelts. These provide potentially attractive lodgement points and subsequent pathways that could allow pest species to establish, reproduce and subsequently spread. Overseas experience has found that if such incursions are not contained and the pests eradicated within two years, subsequent control is virtually impossible.

2. Eradication or control of current invasives. Eradication is generally feasible only at the early stages of colonisation. Once invasives have established, it is generally a matter of minimising spread and numbers through containment strategies.

3. Awareness of future threats. It is important to be aware of the risk of introductions associated with different invasive species. With exotic species, it is easier to determine which species are more likely to enter Australia and to determine their potential range using tools such as climate modelling. Climate change has to be factored into the equation because, with increasing temperatures, the effects on population dynamics of invasive species may be complex as it affects both the invasive species themselves and their natural enemies. The potential effects on native species are more difficult to determine due to our lack of knowledge of most of the native species, and how changes in land use and vegetation patterns across the landscape will affect them.

Another important issue is that society is subject to rapid and sometimes unexpected changes. Some of these changes can accelerate incursion rates and can involve modes and rates of transportation, changes in trading partners and access, and tourism patterns that are difficult to predict. However, recognition of these issues may ensure some allowances are made in the development of future guidelines and predictive models concerning invasive threats to Victoria.

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Challenges in managing miners

Michael F Clarke, Richard Taylor, Joanne Oldland, Merilyn J Grey and Amanda Dare

Department of Zoology, La Trobe University, Bundoora, 3086
Corresponding author: M.Clarke Email: m.clarke@latrobe.edu.au

Abstract
Three of the four members of the genus Manorina have been linked to declines in bird diversity and abundance; they are the Noisy Miner *M. melanocephala*, the Bell Miner *M. melanophrys*, and the Yellow-throated Miner *M. flavigula*. The negative influence of these species in remnant vegetation appears to be spreading in eastern Australia. Some habitat restoration and revegetation programs have the potential to exacerbate the problems associated with these species by inadvertently creating additional habitat for them to dominate. Better understanding of the habitat preferences of miners can guide restoration efforts so that they decrease the likelihood of undesirable outcomes. This contribution is based upon an article that appeared in the *State of Australian Birds Report 2006*, as a supplement to *Wingspan* vol 16, no. 4, 2006. (*The Victorian Naturalist*, **124** (2), 2007, 102-105)

Watching a Noisy Miner *Manorina melanocephala* saunter confidently down a Macquarie Street footpath in central Sydney, picking up lunchtime scraps, one gets the distinct impression that this bird 'owns the place'. Regrettably, for much of eastern Australia this has become the case, to the detriment of many other native birds. Noisy Miners belong to the genus *Manorina* (not to be confused with the introduced Common Myna *Acridotheres tristis* from India). Members of this genus of native honeyeater are renowned for living in complex colonies of kin (Dow and Whitmore 1990; Painter *et al.* 2000) which aggressively defend their communal territory from virtually all other species of bird (Dow 1977). While the Noisy Miner is probably the most familiar member of the genus to most Australians, its close relatives the Bell Miner *M. melanophrys* and the Yellow-throated Miner *M. flavigula* have also been implicated in major changes in bird communities and habitats in different parts of the country (Chandler 1922; Loyn *et al.* 1983; Loyn 1987; Clarke and Schedvin 1999; Ewen *et al.* 2003). Ironically, expansion of the range of the Yellow-throated Miner into formally continuous mallee habitats, has contributed to the decline of the fourth member of the genus, the endangered Black-eared Miner *M. melanotis* (Joseph 1986).

The Noisy Miners' communal defence is so effective that they commonly achieve a virtual monopoly on any piece of habitat they choose to colonise (Dow 1977). Unfortunately, their domination of both rural and urban landscapes is increasing. They are what author Tim Low (2002) has labelled one of the native 'winners' from white settlement, and their ascendancy has

contributed to many other species becoming 'losers'. Although their range within Australia does not appear to be increasing dramatically according to the New Atlas of Australian Birds (Barrett *et al.* 2003), it is their increasing domination of remnant vegetation *within* that range that is of major concern. Some researchers suggest the vast majority of remaining Box woodlands in northern Victoria and southern NSW are already dominated by Noisy Miners (I. Davidson, pers. comm.).

Although it is hard to determine, Noisy Miners were probably much less common prior to white settlement than they are today. Their preferred habitat was probably clumps of eucalypts adjacent to open grassy clearings, not too far from water. Clearing of woodlands and forests for agriculture and urbanisation has inadvertently created tens of thousands of hectares of prime Noisy Miner habitat: lots of grassy clearings edged by eucalypts. Being the adaptable generalists they are, they continue to colonise more and more habitat, to the exclusion of many other native species, some of which, like the endangered Regent Honeyeater, are left with few places to forage unmolested by Noisy Miners.

For many years researchers recognised that where Noisy Miners were present in small remnant woodlands, other small insectivorous birds were less abundant (Dow 1977; Ford and Bell 1982; Ford 1985, 1986; Loyn 1985, 1987; Catterall *et al.* 1991). However, it was unclear whether the absence of small birds was due to the habitat being so degraded that only Noisy Miners could live there, or that the Noisy Miners were excluding the other species. An experimental study conducted by Grey *et al.* (1997, 1998) demonstrated categorically that Noisy Miners were excluding the other species. Upon removal of Noisy Miners from small remnant woodlands, a multitude of small insectivorous birds immediately flooded in and utilised the resources previously unavailable to them. Our research in Grey Box remnants indicated that the level of leaf damage from herbivorous insects decreased following the removal of Noisy Miners, compared to control sites (Grey *et al.* unpubl. data). Through excluding small insectivorous birds from remnant woodlands, Noisy Miners may be contributing to rural tree decline if their territorial behaviour ultimately reduces the level of predation upon defoliating insects. It is likely that the spread of eucalypt dieback will accelerate if there is a further decline in avian diversity in rural and urban landscapes. This is an issue of economic importance to agricultural communities, not just one of aesthetics.

Widespread removal of Noisy Miners from the landscape is not feasible. However, if we understand what makes a site attractive for colonisation by Noisy Miners, we can at least attempt to avoid creating more habitat that suits them. Although Noisy Miners have long been regarded as an 'edge species', until recently there has been little research done to identify how far from edges they will penetrate into remnant vegetation (Piper and Catterall 2003), nor the kind of edges they prefer. Work in both Queensland (Piper and Catterall 2003) and Victoria (Clarke *et al.* unpubl. data) has revealed the disturbing picture that Noisy Miners will commonly dominate as much as 150-300m in from a remnant's edge. This has profound implications for: a) the size remnants need to be to have any 'Noisy-Miner-free' core habitat (> 36 ha) and b) for the width habitat corridors need to be if they are to avoid being dominated by Noisy Miners (> 600 m). Additional research has shown that along remnant edges Noisy Miner colonies typically occur at corners of the remnant, where corridors join the remnant or where clumps or protrusions of canopy vegetation extend into the paddock from the remnant (Taylor 2005).

A major focus of many revegetation efforts to date has been the creation of habitat corridors connecting patches of remnant vegetation to facilitate the movement and dispersal of wildlife across the landscape. Although the studies mentioned above suggest Noisy Miners are very likely to dominate such corridors and diminish their value as dispersal routes for small insectivorous birds, such habitat connections are still extremely important for the conservation of other wildlife such as small mammals and reptiles. In addition to planting corridors of eucalypts, habitat restoration efforts should consider measures for making corridors and the edges of remnants less attractive to Noisy Miners.

Hastings and Beattie (2006) suggest eucalypt plantings supplemented with both bipinnate acacias and a shrubby understorey are less attractive to Noisy Miners. Taylor's (2005) research suggests we should be avoiding the creation of corners, clumps and protrusions in revegetation efforts. Steps could also be taken to enclose protrusions within 100 m of the edge and revegetate out to these new boundaries, with the objective of 'rounding' and 'smoothing' the perimeter of the remnant (Fig. 1). Such extensions of the boundaries of remnants could also preserve isolated hollow-bearing trees in paddocks.

Research we have conducted in the Mallee regions of north-west Victoria suggest the Yellow-throated Miner of the semi-arid and arid zone is having a somewhat similar impact to that of the Noisy Miner (Clarke *et al.* unpubl. data). Yellow-throated Miners are monopolising the thin road-side strips of remnant vegetation that run between the vast paddocks cleared for cereal cropping and grazing. Even small groups of miners (5-10) can successfully exclude the majority of small insectivorous birds that would otherwise move along these vitally important habitat corridors. There is an urgent need to create miner-free refuges in these landscapes, if we are to maintain the remaining diversity of birds.

A third member of the genus, the Bell Miner, has long been linked to eucalypt dieback in forest habitats along the east coast of Australia from Melbourne to Bundaberg (e.g. Chandler 1922). The expansion of the dieback associated with the presence of Bell Miners over the last decade has been so dramatic that it has earned its own acronym – BMAD – Bell Miner Associated Dieback! Tens of thousands of hectares of forest in north-eastern NSW and south-eastern Queensland are affected (Wardell-Johnson *et al.* 2005). Removal experiments by Loyn *et al.* (1983) and Clarke and Schedvin (1999) demonstrated that through their territorial exclusion of other insectivorous species of birds, Bell Miners allow sap-sucking bugs called psyllids to multiply into major infestations that contribute to the death of some canopy tree species. While it is tempting to blame the Bell Miners for this habitat degradation, that begs the question of what it is about a site that predisposes it to hosting an infestation of psyllids (Bell Miner-enhanced or otherwise). It is known that psyllids are phloem feeders that gain their nitrogen from free amino acids and other soluble nitrogen compounds. Young and epicormic foliage of eucalypts is rich in these compounds. This has led people to postulate many different kinds of disturbances that might result in eucalypts putting on a flush of young or epicormic growth that is inadvertently attractive to psyllids, and then Bell Miners (see review by Wardell-Johnson *et al.* 2005). These include stress due to changed hydrological conditions (water-logging or drought), soil pathogens (such as Cinnamon Fungus

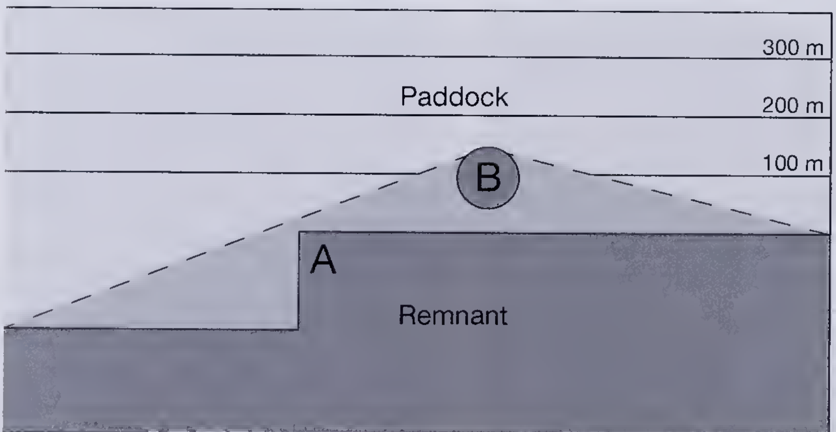

Fig. 1. The edge of a large remnant with two projections: A – a corner and B – a clump. The broken lines highlight the perimeter of the proposed revegetation extending into the paddock, enclosing both projections, and smoothing the remnant

Phytophthora cinnamomi), elevated nutrient levels in the soil, the absence of frequent low-intensity fires, competition from weeds, and micro-climatic changes associated with forest fragmentation and clearing.

While some have advocated the removal of Bell Miners, this does not always result in the recovery of the trees (Clarke and Schedvin 1999). If the psyllid burden is not the primary reason the trees are stressed on a site then they are unlikely to recover just because the psyllid burden is removed. Much more research is needed to identify the factors that predispose a site to infestation by psyllids and colonisation by Bell Miners. Such research should clarify what role, if any, human activities have in making a site attractive and what can be done to avoid or redress any imbalance created.

In conclusion, it must be stressed that these three species of native miner are not behaving in some aberrant manner. They are simply behaving as miners have probably behaved for millennia on this continent. It just happens that we have altered landscapes in ways that have profoundly tipped the balance in their favour – at great cost to many other species. How we have changed the landscape to favour Noisy Miners and Yellow-throated Miners and what can be done to limit the impact these birds have is becoming clear. Whether we will take responsibility for rectifying the mess we have created is less certain.

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Battling Bridal Creeper in coastal dunes – a community approach

Greg Lefoe[1] and Sue Longmore[2]

[1]Department of Primary Industries, Primary Industries Research Victoria, Frankston 3199
Email: greg.lefoe@dpi.vic.gov.au
[2]Swan Bay Integrated Catchment Management Committee, Queenscliff, 3225

Abstract

This paper examines whether a community-based approach to the biological control (biocontrol) of Bridal Creeper *Asparagus asparagoides* L. Druce can be effective in reducing the impact of the weed. Bridal Creeper is a serious threat to native vegetation on Victoria's Bellarine Peninsula. In many situations, such as occurs at Buckley Park Foreshore Reserve, Bridal Creeper can be difficult to control without serious off-target damage. Implementing the biocontrol of Bridal Creeper is therefore seen as a priority. A model for a community-based biocontrol program was adopted on the Peninsula to facilitate the spread and impact of biocontrol agents. The program has required a close collaboration between researchers, land managers, and community groups, including local schools. As a result of the program biocontrol agents have been released at 46 sites on the Bellarine peninsula. Two agents in particular are now spreading and causing visible damage to bridal creeper infestations. The program has demonstrated the important role biocontrol can play in the integrated management of a widespread environmental weed, and provides a strong basis for future collaboration at a local level in weed management issues. (*The Victorian Naturalist* **124** (2), 2007, 106-109)

Introduction

The Bellarine Peninsula is located adjacent to Port Phillip Bay, Victoria. A major threat to native vegetation in the area is the invasive introduced plant Bridal Creeper *Asparagus asparagoides* L. Druce, listed by the Commonwealth government as one of twenty Weeds of National Significance (WoNS) (Thorpe and Lynch 2000). Above-ground parts of the plant can smother native vegetation during the autumn-spring growing season. Although the above-ground parts of the plant senesce during summer, dense underground mats comprising rhizomes and storage tubers may prevent seedling recruitment throughout the year (Raymond 1999). Community groups and local schools on the Bellarine Peninsula have combined with government agencies and land managers to facilitate the implementation of biological control. This paper examines the effectiveness of the collaboration in implementing biocontrol of Bridal Creeper, highlighting Buckley Park Foreshore Reserve as an example of a significant Bellarine Peninsula site threatened by the weed.

Buckley Park Foreshore Reserve

According to the draft Buckley Park Coastal Management Plan (CDA and WE 2005):

> Buckley Park Foreshore Reserve is a unique location consisting of an extensive sand dune and coastal vegetation system with populations of vegetation communities with rare and vulnerable conservation status within the Geelong/Barwon Coast Region and Victoria. The reserve is also rich in both European and Indigenous Australian history further adding to the value of the reserve.

The reserve occupies approximately 5 kms of foreshore and coastal dunes between the townships of Ocean Grove and Point Lonsdale, Victoria, and is managed by the City of Greater Geelong, on behalf of the Department of Sustainability and Environment. Adjacent land managers include the Barwon Coast Committee of Management and Borough of Queenscliff, as well as numerous private landowners (C.D.A. and W.E. 2005). The reserve comprises two Ecological Vegetation Classes (EVCs) in the Otway Plain Bioregion: (i) Coastal Dune Scrub/Coastal Dune Grassland Mosaic (EVC 1) and (ii) Coastal Alkaline Scrub/Calcarenite Dune Woodland (EVC 858). The draft Buckley Park Coastal Management Plan (C.D.A. and W.E. 2005) lists five significant plant communities in the reserve, each of which is threatened by invasive plants. Bridal

Creeper is the most prevalent invasive plant in four of the five listed plant communities.

Managing Bridal Creeper on the Bellarine Peninsula

Controlling Bridal Creeper in areas such as Buckley Park Foreshore Reserve is difficult as manual removal of large infestations is extremely labour intensive, and herbicide controls have potential for serious off-target damage. Even when infestations are controlled, tuber mats may persist; Turner *et al.* (2006), for example, estimated that 50 years after Bridal Creeper is killed up to 35% of the below-ground biomass of the plant may remain. Biological control agents such as the rust fungus *Puccinia myrsiphylla* (Thuem.) may act as a nutrient sink, and help to deplete tuber reserves (Morin *et al.* 2006). Biological control is, therefore, seen as an important part of the integrated management of bridal creeper.

Biological control of Bridal Creeper in Australia

Research into the biocontrol of Bridal Creeper was initiated in the late 1980s (Scott and Kleinjan 1991). One pathogen and two insects have been approved for release in Australia since 1999 (Morin *et al.* 2006). They are, in order of approval: (i) the leafhopper *Zygina* sp. in 1999, (ii) the rust fungus *P. myrsiphylla* in 2000, and (iii) the leaf beetle *Crioceris* sp. in 2002. Approval to release these biocontrol agents followed extensive testing by CSIRO that demonstrated the agents are specific to bridal creeper (Morin *et al.* 2006). In Victoria, the Department of Primary Industries (DPI) has conducted widespread releases of the leaf hopper and rust fungus across the State (Morin *et al.* 2006). The leafhopper and rust fungus have established at most release sites and are dispersing naturally (Holland-Clift and Kwong 2004; unpubl. data). The first release in Victoria of the leaf beetle occurred at Coolart in March, 2005, and it has been released subsequently at just eight locations in the State (Morin *et al.* 2006; unpubl. data).

Implementing biological control of Bridal Creeper on the Bellarine Peninsula

Once a biocontrol agent is approved for release in Australia, there is an opportunity for research agencies to work closely with land managers and community groups to maximise the impact of biocontrol. Holland-Clift and Kwong (2004) proposed a model for a community-based biocontrol program with clearly defined research and extension requirements, and a phased approach to the development and delivery of biocontrol. This is the model largely adopted on the Bellarine Peninsula. As a result, at least 34 leafhopper releases, and 11 rust fungus releases now have been recorded on the Bellarine Peninsula up to 2006 (Longmore 2005, unpubl. data). There has been only one release of the leaf beetle on the Bellarine Peninsula, at Edwards Point. However, establishment at that site is not yet confirmed. The model proposed by Holland-Clift and Kwong (2004) comprises the following phases:

1. Selecting sites for biocontrol

Local knowledge is necessary to select sites suitable for biocontrol and to ensure biocontrol is integrated with local weed management strategies. This works best where biocontrol researchers work closely with local groups and land managers to provide guidance and advise on site selection (Holland-Clift and Kwong 2004). In the case of Buckley Park, local knowledge of factors such as the severity of the Bridal Creeper infestation, potential for off-target herbicide damage, and access difficulties, led to the reserve being identified as a priority for biocontrol.

2. Releasing biocontrol agents

Training and extension activities are essential in the early stages of implementing biocontrol. This ensures local groups and land managers acquire the skills and knowledge to continue, and even expand, programs once they commence. On the Bellarine Peninsula the support of DPI officers was critical for the subsequent success of the biocontrol program. For example, the initial releases of leafhoppers and rust fungus at Buckley Park Foreshore Reserve were made by DPI officers to maximise the likelihood of establishment. However, the opportunity was taken to involve the land manager, community group representatives, and school groups (through DPI's Weed Warriors school program). This involvement included on-site

demonstrations and participation in release techniques, discussion of agent and weed biology, and training in methods to collect and redistribute the agent once it became established.

3. Monitoring release sites
Once agents become widespread it is often difficult for DPI officers to adequately monitor the establishment, spread, and impact of biocontrol agents at all release sites. Community involvement in monitoring sites is therefore important, but has limitations. Community groups should not be asked to collect detailed technical data, as the demands on time may be unrealistic and the quality of the data may vary considerably (Holland-Clift and Kwong 2004). However, community groups on the Bellarine Peninsula have made a valuable contribution by monitoring agent establishment and spread using simple measures developed in collaboration with researchers. In Buckley Park Foreshore Reserve, an ongoing collaboration between the City of Greater Geelong, Barwon Coast Committee of Management, Swan Bay Integrated Catchment Management Committee, and volunteers from the Friends of Buckley Park, has allowed quite detailed data on agent establishment and spread to be collected over several years.

4. Redistributing biocontrol agents once they are established
In their case study, Holland-Clift and Kwong (2004) found 100% establishment of biocontrol agents at new sites when redistribution occurred from a nearby established site, and was accompanied by training and demonstration of collection and release techniques. Holland-Clift and Kwong (2004) concluded it is this phase where community groups, with proper scientific and technical support, can make the greatest impact in a biocontrol program. They stressed though that 'some element of community participation throughout the previous three phases also is necessary in order to select appropriate sites and to refine release and monitoring protocols relevant to the community members' skills and knowledge' (Holland-Clift and Kwong 2004). In this way a compromise can be reached between: (i) the research agency's desire to have trained biocontrol officers conducting and monitoring releases; (ii) the requirement to conduct as many successful releases as possible over a wide area, usually within a specified funding period; and (iii) the need to gain support for biocontrol from land managers and the broader community.

Buckley Park Foreshore Reserve provides an example of all four phases being successfully implemented, with the reserve now being used for biocontrol demonstrations and training, and as a source of rust fungus and leafhoppers for redistribution to new sites. In addition, a new technique for the widespread release of rust fungus was trialled in three areas on the Peninsula, including Buckley Park Foreshore Reserve, in 2006. This new method, called spore-water (a mixture of rust fungus spores and rainwater) allows land managers to inoculate large areas of bridal creeper using conventional spray equipment (Overton and Overton 2006), including aerial application equipment (Fig. 1). Aerial application of the rust fungus may be useful particularly for infestations that are difficult to access from the ground, such as occurs in much of Buckley Park Foreshore Reserve.

In addition to recorded release sites, there are likely to be more releases by members of the local community that have not been recorded. The CSIRO, for example, maintains an interactive web-site that allows the general public to locate release sites in their area (www.ento.csiro.au/weeds/bridal creeper/). This web-site and others (i.e. www.weeds.org.au/WoNS/bridalcreeper/,

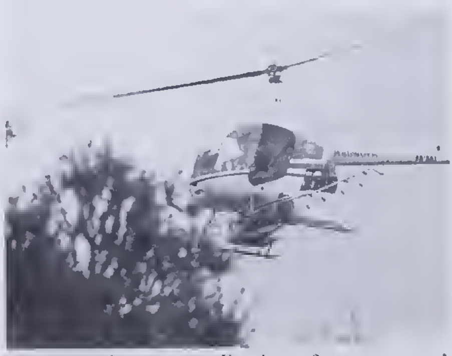

Fig. 1. Helicopter application of 'spore-water' at Buckley Park Foreshore Reserve, September 2006. Photo: Greg Lefoe.

www.dpi.vic.gov.au, and www.weeds.crc.org.au) also provide detailed information on Bridal Creeper management and biological control.

Conclusion

The model for community involvement adopted on the Bellarine Peninsula has enabled many more biocontrol releases to be conducted against Bridal Creeper than would have been possible if DPI were acting with limited collaboration. The extent of the releases, and the success of the agents in establishing and spreading from release sites, have provided a positive experience of biocontrol for the individuals, groups, and schools involved. The leafhopper and rust fungus, for example, are now causing visible damage to Bridal Creeper on the Bellarine Peninsula. The program has demonstrated the important role biocontrol can play in the integrated management of widespread environmental weeds, and provides a strong basis for future collaboration at a local level in weed management issues.

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One Hundred and Twenty Years Ago

THE LOCUST PLAGUE.

A CORRESPONDENT at Murtoa, in the Wimmera district, forwards the following notes on this subject:–

"They appear to be a bit dainty in their tastes, as they ate all the leaves off the 'Scothch thistles,' but would not touch the so-called 'sow thistles,' which is somewhat fortunate, as stock are very fond of the latter. In passing through the crops they took the flag off the wheat, and all the wild oats and wheat, so that in several places there is nothing left but the ears of wheat on the tops of bare stems. they cut off a few ears of wheat, but they were in all cases those of shorter and later straws; the others appear to have been too hard for them..

From *The Victorian Naturalist* **3** p. 131, February 1887.

The potential impact of the Large Earth Bumblebee *Bombus terrestris* (Apidae) on the Australian mainland: Lessons from Tasmania

Andrew B Hingston

School of Geography and Environmental Studies, University of Tasmania, Private Bag 78, Hobart, Tasmania,7001. Email: hingston@utas.edu.au.

Abstract

The Large Earth Bumblebee *Bombus terrestris* (L.) (Hymenoptera: Apidae) is an invasive species that has not yet established on the Australian mainland. However, a feral population was discovered in Tasmania in 1992 and applications have been made to import the species to the Australian mainland for pollination of crops inside greenhouses. The introduction of *B. terrestris* to the Australian mainland for pollination of greenhouse crops poses a potential threat to Australia's biodiversity because: (1) *B. terrestris* is likely to escape from captivity and form feral populations in the wild across a large area; (2) *B. terrestris* forages on many species of native and introduced plants and has spread rapidly throughout all major native vegetation types in Tasmania; (3) *B. terrestris* is able to reduce the amounts of nectar available to other animals by foraging at lower temperatures than other bees; and (4) the effectiveness of *B. terrestris* as a pollinator sometimes differs from that of other animals. Recent research suggests that *B. terrestris* is reducing reproductive success in an endangered species of bird in Tasmania by reducing nectar availability, and several species of introduced plants have become more invasive in Tasmania since *B. terrestris* arrived there. (*The Victorian Naturalist* **124** (1) 2007, 110-117)

Introduction

The Large Earth Bumblebee *Bombus terrestris* (L.) (Hymenoptera: Apidae) is an invasive species that has not yet established itself on the Australian mainland, but has been present in Tasmania since 1992 (Semmens *et al.* 1993). Concern about the potential for its establishment on mainland Australia has already led to *B. terrestris* being listed as a threatening process in both Victoria and New South Wales (Lefoe and Backholer 2002;Whelan *et al.* 2004). It is, therefore, important for people living on the Australian mainland to become familiar with *B. terrestris,* and its potential impacts, to maximize the chances of any founder populations being reported as soon as possible to relevant government agencies. Early detection provides the best chance of preventing *B. terrestris* from establishing feral populations on the Australian mainland.

Bombus terrestris is a heavily-built, hairy bee with broad black and golden-yellow bands. It varies greatly in size, with body lengths ranging from 8 mm up to 35 mm. The larger individuals make a loud buzzing sound and are often heard before they are seen. This species has annual colonies in pre-existing cavities in or near the ground and comprises three castes. Queens are the largest caste and these establish the colonies on their own after having mated with a drone. The queen collects nectar and pollen from flowers to feed her first batch of larvae which develop into workers. The adult workers then take over the role of collecting food to feed subsequent batches of larvae and the colony grows in size until worker production is replaced by production of new queens and drones. After worker production ceases the adult workers gradually die off and, with the decline of numbers of bees collecting nectar and pollen, the colony and original queen eventually die out. The new queens then mate with drones and establish new colonies (Cumber 1953; Donovan and Macfarlane 1984; O'Toole and Raw 1991; Prys-Jones and Corbet 1991).

Bombus terrestris is currently expanding its range across the world because of human assistance. The natural distribution of *B. terrestris* encompasses most of Europe, as well as the near east, Mediterranean islands, part of the north coast of Africa, the Canary Islands and Madeira (Estoup *et al.* 1996; Widmer *et al.* 1998; Chittka *et al.* 2004). The British subspecies *B. terrestris audax* (Harris) was

also introduced successfully to New Zealand from England in 1885 (Hopkins 1914). This was the extent of the global distribution for over 100 years. However, in 1987 the horticulture industry started using *B. terrestris* to improve pollination of greenhouse crops, particularly tomato *Solanum lycopersicum* L. (Velthuis and van Doorn 2006). Colonies of *B. terrestris* have subsequently been sold to growers of greenhouse tomatoes, not only within the natural distribution of *B. terrestris* and New Zealand, but also, in Iceland, Finland, Jordan, Saudi Arabia, Mexico, Chile, Argentina, Uruguay, South Africa, Taiwan, China, South Korea and Japan (Hingston *et al.* 2002; Australian Hydroponic & Greenhouse Association 2005; Velthuis and van Doorn 2006). *Bombus terrestris* has escaped from greenhouses and formed feral populations in Japan (http://www003.upp.so-net.ne.jp/consecol/english/maruhana/maruhana_info_eng.html; Matsumara *et al.* 2004), Chile (Ruz and Herrera 2001), Mexico and Uruguay (Australian Hydroponic & Greenhouse Association 2005).

Approval has not been given to import *B. terrestris* to Australia. However, two applications have been made to import *B. terrestris* to the Australian mainland for the pollination of greenhouse crops. The first of these (Goodwin and Steiner 1997) was rejected (Goodwin and Steiner 1999). However, another organization has recently reapplied (Australian Hydroponic & Greenhouse Association 2005) and this is currently being assessed by the Australian Department of Environment and Heritage.

Australia has a poor history of importing animals because it seemed like a good idea at the time, only to discover that it wasn't such a great idea after all (Low 1999). The lessons from this history are that it is important to assess carefully the risks associated with any proposed introduction of an exotic animal. Pest risk associated with introduction of non-native organisms has been defined as a function of: the risk of escaping from captivity; the risk of establishing outside captivity; the organism's potential geographic range; the organism's potential abundance within that range; and the organism's per capita effect on the ecosystem (Bigsby and Crequer 1998; Parker *et al.* 1999). This paper considers the risk of *B. terrestris* becoming a pest as a result of its proposed use inside greenhouses on the Australian mainland (Australian Hydroponic & Greenhouse Association 2005).

The risk of *Bombus terrestris* escaping from captivity

Colonies of *B. terrestris* can be started only by queens. Therefore, preventing queens escaping from hives could be an effective way of preventing a feral population from establishing. The likelihood of queens escaping from greenhouses can be reduced by adjusting the diameter of the hive's entrance to make it too small for queens to pass through while remaining large enough for workers to exit the hive and pollinate tomatoes (Thorp 2003; Australian Hydroponic & Greenhouse Association 2005; Ings *et al.* 2006). Unfortunately, this is not 100% effective at preventing queens from escaping from the hive into the greenhouse (Griffiths 2004; Australian Hydroponic & Greenhouse Association 2005). A representative of the bumblebee-production industry has stated 'On average, the pollinating life of a hive is some 8 to 10 weeks, at which time emerging bees are all males, sometimes followed by the emergence of new queens. Over 50% of hives within the greenhouse can expect to produce these queens. The diameter of the flight hole is such that it should prevent the egress of the larger-sized queens, but in practice, some queens and males escape into the glasshouse environment. Thus, whilst not all commercial hives will produce queens and the number per hive will be small, some can be expected to escape into the natural environment, where they will be fertilised by escaping males' (Griffiths 2004).

The risk of *Bombus terrestris* establishing outside captivity

Supporters of the introduction of *B. terrestris* to the Australian mainland have also stated that queens will escape from the greenhouses and produce feral colonies. Griffiths (2004) stated 'there is a risk that a limited number of fertilised queens will escape from commercial glasshouses into the environment. Whilst the overall num-

bers will be few, some feral colonies will establish'. Similarly, the previous submission to import *B. terrestris* to the Australian mainland stated 'While it is not the intention to establish feral populations, it is anticipated that improper use or accident could result in bumblebees establishing in the wild' (Goodwin and Steiner 1997). The establishment of feral populations of *B. terrestris* in Japan (Matsumara *et al.* 2004; http://www003.upp.so-net.ne.jp/consecol/english/maruhana/maru-hana_info_eng.html), Chile (Ruz and Herrera 2001), Mexico and Uruguay (Australian Hydroponic & Greenhouse Association 2005), as a result of escape from greenhouses, clearly supports their view.

The potential geographic range of *Bombus terrestris* on the Australian mainland

There is some uncertainty surrounding the area over which *B. terrestris* could establish on the Australian mainland. However, a consultant's report produced as part of the recent proposal to import *B. terrestris* to the Australian mainland indicates that this area is likely to be substantial. McClay (2005) produced two CLIMEX models to predict the potential geographic range of *B. terrestris* across mainland Australia. Model 1, based on the range of climates within the natural distribution of *B. terrestris,* predicted that *B. terrestris* could spread across most of Victoria, the eastern half of NSW, almost all the way up the Queensland coast, south-eastern SA, and a large area in south-western WA from Eyre to Geraldton. Model 2, based on the range of climates in the British Isles where subspecies *B. terrestris audax* occurs, predicted that this subspecies would be restricted to a smaller area comprising coastal and high elevation areas in Victoria and southern NSW south of Sydney, a small area in south-eastern SA, as well as high altitude areas around Armidale in northern NSW. However, this area, which is greater than the size of Tasmania, is the absolute minimum over which *B. terrestris audax* would spread (McClay 2005). In the absence of evidence that the natural range of *B. terrestris audax* is constrained by climate rather than the North Sea and English Channel, McClay (2005) concluded that *B. terrestris audax* 'could establish in broader areas of Australia, possibly approaching the limits of the potential distribution of *B. terrestris sensu lato*' as determined from Model 1.

The potential abundance of *Bombus terrestris* within its predicted range

The density at which *B. terrestris* will occur if it establishes on the Australian mainland is also uncertain. However, observations of *B. terrestris* in Tasmania suggest that it is capable of becoming a major component of flower visitor faunas within climatically suitable areas on the Australian mainland. *Bombus terrestris* can reproduce successfully in indigenous Australian vegetation. A colony excavated in a Tasmanian national park produced at least 304 new queens and 939 workers/drones (Hingston *et al.* 2006). *Bombus terrestris* also sometimes comprises large parts of flower visitor faunas in Tasmania. For example, it comprised 43% of visits to flowers of *Gompholobium huegelii* Benth. (Hingston and McQuillan 1999), up to 92% of flower visitors to *Eucalyptus ovata* Labill. (AB Hingston, SA Mallick and S Wotherspoon unpubl. data.), and up to 100% of flower visitors to Tree Lupin *Lupinus arboreus* Sims (Stout *et al.* 2002).

The per capita effect of *Bombus terrestris* on the ecosystem

Determining the effect that *B. terrestris* is having on the Tasmanian ecosystem will require a great deal more research. Potential harmful impacts that *B. terrestris* could have include: '(1) competition with native animals for nectar and/or pollen of native plants; (2) reduced seed production and/or altered gene flow in native plants; and (3) increased seed production in introduced weed species' (Hingston 2005). The potential for these three impacts to occur depends upon the foraging preferences of *B. terrestris* because the first two are dependent upon *B. terrestris* foraging on native plants and invading native vegetation while the third impact could result from foraging on introduced species of plants.

Proponents of the introduction of *B. terrestris* to the Australian mainland have consistently argued that *B. terrestris*

causes little harm in Tasmania because it prefers to forage on introduced species of plants and rarely invades native vegetation (Goodwin and Steiner 1997; Carruthers 2003; Griffiths 2004; Australian Hydroponic & Greenhouse Association 2005). However, 'even if bumblebees do concentrate their foraging on introduced plants, they could still have serious impacts on native plants and the native animals that feed from their flowers if some introduced plants produce more seeds as a response to pollination services by bumblebees and consequently become more invasive and outcompete the native plants' (Hingston 2005). An example of this is the South African lily *Agapanthus praecox* Willd. subsp. *orientalis,* which was not listed as naturalised in the late 1990s in Tasmania (Rozefelds *et al.* 1999) but is now regarded as an environmental weed around Hobart and the Tasmanian coast (Connolly *et al.* 2004; Hingston *et al.* 2005). This apparent increase in invasiveness may have been caused by *B. terrestris* because it appears to be the major pollinator of *A. praecox* in Hobart (Hingston 2006b). *Bombus terrestris* is the most common visitor to the flowers of *A. praecox* in Hobart, contacts the stigma and anthers far more frequently than does the only other regular visitor, and carries significantly more pollen of *A. praecox* than does the only other regular visitor (Hingston 2006b). Similarly, *Rhododendron ponticum* L. was not recorded as naturalised in the late 1990s (Rozefelds *et al.* 1999). However, large numbers of seedlings have recently been seen at several locations in western Tasmania, just outside the Tasmanian Wilderness World Heritage Area (M Baker 2005 pers. comm. 9 Nov.). It is likely that *B. terrestris* has caused the naturalisation of *R. ponticum* because bumblebees are known to be major pollinators of *R. ponticum* in Europe (Mejías *et al.* 2002; Stout *et al.* 2006). Another invasive plant in Tasmania that may be benefiting from pollination services provided by *B. terrestris* is *Buddleia davidii* Franchet, which has also become more invasive since the arrival of *B. terrestris* (A Crane 2005 pers. comm. 14 Nov.). Because its stigma is situated 5-7 mm along a narrow tubular corolla (AB Hingston pers. obs., see also Webb *et al.* 1988), only animals with tongues of this length or more are likely to deposit pollen on the stigma. The proboscises of *B. terrestris* – queens 8-11 mm, (Brian 1954); drones 8.1 mm (Medler 1962); workers 6.9-9.3 mm (Prys-Jones and Corbet 1991) – are long enough to contact the stigma in almost all cases, whereas those of the only other common visitor to flowers of *B. davidii* in Tasmania, the Honey Bee *Apis mellifera* L. (5.3-7.2 mm, Ruttner *et al.* 1978), are probably less likely to contact the stigma.

It is also possible that *B. terrestris* is harming Tasmanian native fauna and flora directly, because the claims that *B. terrestris* prefers to forage on introduced species of plants and rarely invades native vegetation in Tasmania (Goodwin and Steiner 1997; Carruthers 2003; Griffiths 2004; Australian Hydroponic & Greenhouse Association 2005) are contrary to a large volume of peer-reviewed research (Hingston and McQuillan 1998a,b, 1999; Olsson *et al.* 2000; Hingston *et al.* 2002, 2004b, 2006; Hingston 2005, 2006a). The only study in Tasmania that considered the relative numbers of flowers of introduced and native plants in the study area while testing the foraging preferences of *B. terrestris* found that 'The numbers of bumblebees seen foraging per 1000 flowers did not differ significantly between introduced plants and Australian native plants, and the preferred food sources of bumblebees included flowers of both introduced and Australian native species' (Hingston 2005). Indeed, it was known 10 years ago that *B. terrestris* was foraging on a wide variety of native plants in several types of native vegetation near Hobart (Hingston and McQuillan 1998a). By five years ago, *B. terrestris* had been found in 'all of Tasmania's major (native) vegetation types, altitudes from sea level to 1260 m ASL, and the entire breadth of annual precipitation in the state' (Hingston *et al.* 2002). During the summer of 2004-2005 'More than 10 bumblebees were seen in one day at 153 locations in native vegetation, including 42 locations within 10 National Parks and 38 locations within the Tasmanian Wilderness World Heritage Area' (Hingston 2006a). Further evidence of the capacity of *B. terrestris* to invade

Tasmanian native vegetation and forage on native plants comes from the excavation of a nest in Maria Island National Park in May 2005. This colony produced at least 304 new queens and 939 workers/drones on a diet that appeared to comprise almost entirely native plants, because at least 95.3% of the pollen stores in the nest were from native plants, with 84.5% being from *Eucalyptus* (Hingston *et al.* 2006).

This capacity for *B. terrestris* to invade native vegetation and forage on native plants in Tasmania means that it is a potential competitor of a wide range of native animals. The foraging profile of *B. terrestris* in native vegetation near Hobart 'overlapped with those of all anthophilous insect families, all bee subgenera, and all species of nectarivorous birds which were encountered' (Hingston and McQuillan 1998a). At this stage there has been little research into the competitive effects of *B. terrestris* on Tasmanian fauna, although there is some evidence of *B. terrestris* competing with native bees. In the presence of *B. terrestris,* native megachilid bees visited fewer flowers per hour, fewer flowers per foraging bout, spent less time per flower, and spent less time foraging, which suggests that they were being displaced through resource competition (Hingston and McQuillan 1999). However, it is not known if this translates into lower reproductive output in the megachilid bees. Indeed, we almost certainly do not have a complete list of the species of bees that occur in Tasmania (Hingston 1998, 1999), let alone know what impact *B. terrestris* is having on them. Stronger evidence of competition from *B. terrestris* reducing reproductive output in a native animal comes from observations of *B. terrestris* foraging heavily on *Eucalyptus globulus* Labill. (Hingston 2002; Hingston *et al.* 2004a,b) and *E. ovata* Labill. (AB Hingston, SA Mallick and S Wotherspoon unpubl. data). Reduced food availability in these plants is likely to reduce reproductive success in the nationally endangered Swift Parrot *Lathamus discolor* (Shaw), because its breeding success is limited by the availability of nectar and pollen of these two species of tree (Swift Parrot Recovery Team 2001; Gartrell 2002; AB Hingston 2002–2006 unpubl. data). Comparisons of the amounts of nectar in bagged and exposed flowers of *E. ovata* in the outer Hobart suburb of Mt Nelson revealed that *B. terrestris* sometimes has a marked effect on the amount of nectar available to Swift Parrots, particularly at low ambient temperatures. On a warm day (17 Nov. 2002, maximum temperature 28.2°C), *B. terrestris* commenced foraging at 7.00 am and the amount of nectar in exposed flowers declined between 7.00 am and 8.00 am to less than half of that in bagged flowers. This decline can be attributed only to foraging by *B. terrestris* because the only other common visitors to the flowers, Honey Bees, did not start foraging until 9.00 am (AB Hingston, SA Mallick and S Wotherspoon unpubl. data). On a day that was too cold and showery for Honey Bees to forage (6 Dec. 2002, maximum temperature 12.8° C), *B. terrestris* foraged from *E. ovata* continuously from 6.00 am until 6.00 pm and comprised 92% of all flower visitors on that day. During this time, the amounts of nectar in exposed flowers remained low while those inside bags increased markedly (AB Hingston, SA Mallick and S Wotherspoon unpubl. data). Hence, *B. terrestris* appeared to consume all of the diurnal nectar production on this day, which would clearly reduce the amount available to Swift Parrots. Evidence that reproduction in Swift Parrots was limited by food availability in this situation comes from the fact that, although 120 Swift Parrots foraged predominantly on flowers of *E. ovata* throughout this breeding season at Mt Nelson, few chicks were fledged. Single fledglings were observed on only three occasions (4, 29 and 30 Dec. 2002), with the last of these observations being of a fledgling on the ground that was too weak to fly (AB Hingston 2002 unpubl. data). The capacity for *B. terrestris* to remove nectar from flowers at times when it is too cold for Honey Bees to forage (AB Hingston, SA Mallick and S Wotherspoon unpubl. data), suggests that *B. terrestris* could also reduce nectar availability to commercial Honey Bees. Indeed, Tasmanian apiarists appear to be very concerned about the threat that *B. terrestris* poses to their industry. I was invited to present a seminar at the Tasmanian Beekeepers' Association

AGM in 2005, and delegates were very worried about this threat.

By invading native vegetation and foraging on many species of native plants in Tasmania, *B. terrestris* could also affect seed production in native plants. However, few studies have investigated this. *Bombus terrestris* appears to be able to pollinate *Eucalyptus globulus,* although it is not very effective at this. Single visits to flowers by *B. terrestris* resulted in less than 10% as many seeds as did single visits by Swift Parrots (Hingston *et al.* 2004b). Hence, in situations where more effective pollinators such as Swift Parrots are scarce, *B. terrestris* might increase seed production. However, if *B. terrestris* displaces pollinators that were more effective, the net effect could be a decline in seed set. *Bombus terrestris* may also reduce seed production by displacing effective pollinators from flowers with tubular corollas that it robs of nectar. This involves *B. terrestris* biting holes through the bases of tubular corollas to access nectar, if the corolla tube is too long for *B. terrestris* to reach nectar by probing through the corolla throat, thereby avoiding contact with anthers and stigmas and not pollinating the flower. *Bombus terrestris* has been observed robbing the native species *Epacris impressa* Labill. (Hingston and McQuillan 1998b), *Richea scoparia* Hook. f. (Olsson *et al.* 2000), *R. dracophylla* R. Br., *Billardiera longiflora* Labill., and a *Correa* cultivar with tubular corollas in Tasmania (AB Hingston pers. obs.).

Conclusions

The introduction of *B. terrestris* to the Australian mainland for pollination of greenhouse crops poses a potential threat to Australia's biodiversity because *B. terrestris* is likely to escape from captivity and form feral populations in the wild across a large area, it forages on many species of native and introduced plants and has spread rapidly throughout all major native vegetation types in Tasmania, it is able to reduce the amounts of nectar available to other animals by foraging at lower temperatures than other bees, and the effectiveness of *B. terrestris* as a pollinator sometimes differs from that of other animals.

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Hybridisation and invertebrate hosts – two neglected aspects of pest plants in south-eastern Australia

Randall W Robinson

Victoria University, Faculty of Health Engineering and Science,
St Albans Campus, PO Box 14428, MCMC, Victoria, 8001.

Abstract
Many of the threats to our native flora, including habitat destruction, weed infestations, rabbits, are glaringly obvious. Hybridisation between native and 'introduced' species and introduced plant species acting as hosts for introduced pests are two threats that are generally overlooked by the casual observer. Examples are given of these two threats to our native plants. The implications of hybridisation and introduced plants acting as hosts on the long-term survival of our natural heritage are discussed. (*The Victorian Naturalist*, **124** (2), 2007, 117-122)

Introduction

The impact of introduced plants in Australia has gained national attention of late, being ranked as one of the highest risks to both economic and biodiversity values. The Co-operative Research Centre (CRC) for Australian Weed Management estimates that the cost of weeds to agriculture alone is in the vicinity of $4 billion per year (CRC for Australian Weed Management 2003). This figure does not take into consideration the impact of weeds on natural ecosystems, the potential loss of biodiversity values or the impacts on human health, most notable on hay fever sufferers (CRC for Australian Weed Management 2003).

It is estimated that there are 2 700 naturalised plant species in Australia, many of which were deliberate introductions for agricultural or ornamental use (Muyt 2001). Three hundred and seventy of these species are now of critical importance

Fig. 1. *Pittosporum bicolor* (Left), *Pittosporum undulatum* (Right) and hybrid (Middle).

(declared noxious in various states of Australia) and the focus of major control efforts (Thorp and Lynch 2000). In Victoria alone, there are over 580 taxa that are listed as major threats to either agriculture or the environment (DSE 2006). There is a range of national and state programmes to address the problem of weeds, the most notable being the Weeds of National Significance Programme and the Weeds and Pests on Public Land Initiative. This latter initiative is funded to the value of $14 million over a period of four years (DSE 2006).

Assessment of the impacts on biodiversity can be particularly hard to quantify, especially in an economic sense. However, the direct threats on particular plant, animal and vegetation communities can be noted. The Victorian *Flora and Fauna Guarantee Act* 1988 (FFG), has the provision for the listing of potentially threatening processes (PTPs). It is interesting to note that of the 36 presently-listed PTPs, five directly implicate weed invasions:

1. Invasion of native vegetation by Blackberry *Rubus fruticosus* spp. agg.
2. Invasion of native vegetation by 'environmental weeds'
3. Introduction and spread of *Spartina* to Victorian estuarine environments
4. Spread of *Pittosporum undulatum* in areas outside its natural distribution
5. Degradation of native riparian vegetation along Victorian rivers and streams.

In action statements prepared under the FFG Act 1988, 11 vegetation communities and 111 plant species are also considered directly threatened by weed invasions, with mention in each of these action statements of weed invasions (DSE 2006). Interestingly, it is not only plants that are threatened by weed invasions but a range of animals as well, most notably the Mountain Pygmy Possum *Burramys parvus* (DSE 2006).

While such direct threats as those listed above are commonly cited and are actively dealt with, there is a range of other less obvious and potentially more insidious impacts of pest plants that go unnoticed by many.

Hybridisation

Hybrid plants are the mainstay of our horticultural and agricultural industries but what happens when these plants occur in the 'wild'? Robin and Carr (1986) highlighted the issue of hybridisation between indigenous and introduced species and provided 19 examples from the genera *Acacia*, *Coprosma*, *Epilobium*, *Grevillea*, *Nicotiana* and *Pittosporum*. Twenty years later, hybridisation between indigenous and introduced plants still receives little attention but would appear to be an even greater risk than originally thought. A few examples may help to illustrate this point.

Banyalla *Pittosporum bicolor* is a small native tree that occurs in damp forest in the higher rainfall areas of Victoria, generally at higher elevations (Otways, Central Highlands, Central and East Gippsland) New South Wales and Tasmania. Conversely, Sweet Pittosporum *Pittosporum undulatum* is a large understorey tree of the lowlands originally confined to rainforest gullies of Victoria (South and East Gippsland), New South Wales and Queensland. The desirability of *P. undulatum*, for garden use, led to its introduction to gardens throughout Australia and indeed warmer parts of the world, soon after colonisation. The first record of hybridisation between these two species was not recognised as a hybrid when Morris and Curtis (1974) described the species *Pittosporum undulatum* var. *emmettii* from Tasmania. Since 1974, botanists have recognised the hybrid origin of this taxon and found it throughout the entire range of *P. bicolor* (Flora Information Service, DSE) (Fig. 1)

Silver Wattle *Acacia dealbata* is one of the most widespread wattles in Victoria, New South Wales and Tasmania, generally occurring in damp to wet forest and along rivers and drainage lines. Cootamundra Wattle *Acacia baileyana* is a small tree, naturally occurring in a small, low rainfall area around the Cootamundra to the Wagga-Wagga area of southern inland NSW. Like *P. undulatum*, *A. baileyana* is a very popular garden plant and widely naturalised in south-eastern Australia and several countries throughout the world. Hybrids between *A. baileyana* and *A. dealbata* were first noticed in the early 1980s (Flora Information Service, DSE). The hybrids between these two acacias have inherited characteristics from each parent

Table 1 List of hybrids between indigenous and introduced/ introduced native species in South-eastern Australia (Flora Information Service, DSE).

Acacia longifolia subsp. *longifolia* x *mucronata*
Acacia longifolia subsp. *longifolia* x *oxycedrus*
Coprosma hirtella x *robusta*
Coprosma quadrifida x *repens*
Correa reflexa x *glabra*
Epilobium billardiarianum x *ciliatum*
Eucalyptus botryoides x *camaldulensis*
Eucalyptus globulus subsp.*globulus* x subsp. *pseudoglobulus*
Eucalyptus leucoxylon subsp. *bellarinensis* x subsp. *megalocarpa*
Eucalyptus leucoxylon subsp. *connata* x subsp. *megalocarpa*
Eucalyptus nitens x *ovata*
Grevillea rosmarinifolia x various species and hybrids
Hardenbergia comptoniana x *violacea*
Hardenbergia 'Happy Wanderer' *(comptoniana x violacea)* x *violacea*
Leptospermum laevigatum x *mysinoides*
Melaleuca armillaris x *ericifolia*
Nicotiana glauca x *suaveolens* (Nicotiana flindersiesis)
Nicotiana glauca x *velutina*
Pittosporum bicolor x *undulatum*

Table 2. Native forb genera on which RLEM have been observed to feed. * = very sensitive

Ajuga	*Kennedia*	*Rutidosis**
Arthropodium	*Leucochrysum*	*Stylidium**
*Brachyscome**	*Lotus**	*Swainsona*
*Craspedia**	*Microseris**	*Velleia*
Cullen	*Minuria*	*Wahlenbergia**
Glycine	*Podolepis*	*Xerochrysum*
Goodenia	*Pterostylis*	

that make them a cause for concern: from *A. dealbata* they have inherited the habit of extensive clonality (suckering), from *A. baileyana* drought tolerance (pers. obs.) These hybrids can be found growing in a wide range of habitats, from damp forests and rivers to dry hilltops, forming large vegetatively produced colonies tens of metres across (pers. obs.).

These are just two of the increasing number of species that are found to be hybridising in bushland areas throughout south-eastern Australia. What is the long-term impact of this type of 'genetic pollution' (Robin and Carr 1986) on our biological heritage? In all likelihood, several of our plants may be hybridised out of existence. In some cases, most notably *Grevillea rosmarinifolia* 'Hurstbridge Form', this already may have happened. Table 1 lists some examples of known hybrids.

Weeds as harbour for invertebrate pests

During studies carried out on the recruitment of grassland forbs in Victoria (Robinson 2005), it became evident that the introduced Red-legged Earth Mites *Halotydeus destructor* (RLEM) were feeding heavily on mature plants of many indigenous species. The feeding of the RLEM was causing considerable damage to the mature plants, in some cases weakening them to the point of death or in some cases preventing flowering. Investigations into RLEM revealed that they are a major problem in agricultural crops, reducing recruitment by up to 86% in Lucerne, Canola and various clovers (Liu and Ridsdill-Smith 2000).

Red-legged Earth Mites were introduced into Australia from South Africa in 1914 (Liu and Ridsdill-Smith 2000). Interestingly, in their home country, they feed primarily on members of the Daisy family (Asteraceae) and Pea family (Fabaceae) (Annells and Ridsdill-Smith 1994). One of their host plants in South Africa is the now ubiquitous Capeweed *Arctotheca calendula* (Annells and Ridsdill-Smith 1994). The mites cause very little damage to Capeweed apart from the odd stippling of leaves and slightly larger dead patches on leaves where they have extracted the contents of individual

Fig. 2. *Acacia baileyana* x *dealbata* on a dry hillside at Cottles Bridge, Victoria.

cells in the leaf (pers. obs.). The distribution of this pest is generally in south-eastern and south-western Australia at elevations below about 300 m. The distribution of this species coincides with the distribution of lowland grasslands and grassy woodlands in southern Australia (Lui and Ridsdill-Smith 2000).

A survey of plants susceptible to the privations of RLEM carried out by the author revealed that it was not only the agricultural crops and indigenous natives that were sensitive. Some of our most common and widespread weeds are sensitive to RLEM or act as host to the species. Most of the 'thistles' including Spear Thistle *Cirsium vulgare* and Variegated Thistle *Silybum marianum* host large numbers of this pest but still seem able to survive and reproduce (pers. obs.). Other species including several of the Chickweeds, particularly *Stellaria media* and *Cerastium glomeratum*, Shepherds Purse *Capsella bursa-pastoris*, and even the horticulturally desirable *Cyclamen* species are particularly sensitive hosts.

Light infestations of the above-listed introduced weed species, which occur in even the most intact grasslands and grassy woodlands, would provide harbour for RLEM. The spread of RLEM-sensitive weeds and their dominance of some vegetation types, coupled with infestations of RLEM, may be putting enormous pressure on our indigenous forb species. Observations by Neville Scarlett (pers. comm.) indicate that several of the Snout Mites, predatory mites that feed on RLEM, may be absent from 'disturbed' grasslands. Scarlett further observes that many of the indigenous species are sensitive to RLEM and the equally widespread Blue Oat Mite *Penthaleus major*.

The importance of weed control, coupled with invertebrate control, may be one of the keys to allow the successful recruitment and conservation of our indigenous forb species. Table 2 contains a short list of some of the genera sensitive to attack by RLEM.

Long-term implications

The hybridisation of indigenous and introduced species and the hosting of invertebrate pests by weeds could have long-term implications for the structure and floristics of plant populations. Alterations to the genetic make-up of populations, particularly the changes brought about by the mixing or homogenisation of formerly distinct

Fig. 3. *Acacia baileyana* (Left), *Acacia dealbata* (Right) and hybrid (Middle).

Fig. 4. Red-legged Earth Mites on the underside of a leaf of Shepherds Purse *Capsella bursa-pastoris*. Necrotic areas are damage caused by RLEM.

species, may bring about extinctions of some plants, even some of the most common species. The physical and ecological attributes of hybrid entities, particularly wider ecological amplitudes exhibited by the examples given above, extensive clonality and larger size may lead to replacement not only of the original species subject to hybridisation, but other species as well. In the case of *Pittosporum bicolor* x *undulatum*, the hybrid plant has most of the attributes of the introduced parent: larger size, denser canopy and more prolific flowering. This will lead to stronger competition with other plants, particularly for light and water. In the case of *Acacia baileyana* x *dealbata*, the strong suckering habit and much wider ecological tolerances of the hybrid will allow a wide range of vegetation communities to be invaded, with the consequent flow-on effects.

Genetic 'pollution' is difficult to assess and not readily evident to the casual observer. Complete replacement of the original genetic entity with the hybrid may not be evident until there is a recruitment event. This may be analogous to the case of the Red-tailed Black Cockatoo where there would appear to be many individual animals. It is not until there is an analysis of the age

structure of the population that it is realised that there are no young birds and most of the older birds are beyond reproductive age. In the case of *Grevillea rosmarinifolia*, there would appear to be many plants until one notices that all of the seedlings are of hybrid origin and the older plants are dying or unthrifty.

In the case of RLEM, predation of the seedlings of many of the grassland forbs may be creating a similar scenario to that described above. Many of the grassland forb species are long-lived perennials. Unfortunately, there is little evidence of recruitment of these species but the process of death and decay of the older plants continues apace. One or a few episodic events, a particularly bad drought or intense fire, could eliminate older plants, leaving little or no ability for recruitment within the population. Incremental and imperceptible loss becomes a sudden loss in these situations.

To overcome the above problems there is a need for intervention and further investigation of the problem. To date, there is little information to inform management decisions, particularly the setting of priorities and understanding the genetics or influence of hybridisation on the genetic makeup of populations. Additionally, there is a need for investigations into the recruitment dynamics of plants and the impact of weed invasions on recruitment, either directly or indirectly, and their impacts on vegetation dynamics in general. Controlling weeds is only a part of the solution to achieve what is in fact our primary goal: the attainment of high quality sustainable plant and animal communities.

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One Hundred and Twenty Years Ago

THE LOCUST PLAGUE.

A CORRESPONDENT at Murtoa, in the Wimmera district, forwards the following notes on this subject:–

"They appear to fly in swarms, in size varying from a few yards wide to over a mile, and of great length, as sometimes the flight continues from half an hour to an hour without the slightest break. They fly about 20 to 25 feet above the ground, and seem to be able to sustain themselves on the wing for a long distance, and I fancy those which rest, except for feeding purposes, are younger and weaker than the company they are in. They evidently camp at night. I went out about half-past eight for the purpose of catching some; they were all on the move as soon as they heard me, but only used their legs, and did not attempt to fly. They did not do much damage to the wheat crops in this district; but the grass paddocks were cleared right off in a day or two, so that the farmers will be obliged to sell their sheep at once for what they will fetch, as they have no feed left."

From *The Victorian Naturalist* **3** p. 131, February 1887

New combinations in the terrestrial orchid genera *Caladenia* R.Br. and *Pterostylis* R.Br. (Orchidaceae) for Victoria, Australia

Gary N Backhouse

Department of Sustainability and Environment, Biodiversity and Ecosystem Services Division, 8 Nicholson Street, East Melbourne 3002
Email Gary.Backhouse@dsc.vic.gov.au

Abstract
New combinations are made in the terrestrial orchid genera *Caladenia* R.Br. and *Pterostylis* R.Br. to accommodate new species described in genera not presently recognised in Victoria. (*The Victorian Naturalist* **124** (2), 2007, 123-124)

Introduction

There have been many changes to the taxonomy of Australian orchids in recent years, at both the genus and species level. Over 90 new taxa were described in 2006 alone (Jones 2006a; 2006b; Jones and Clements 2006; Jones and Rouse 2006; Jones *et al.* 2006). Some of this taxonomy has been controversial, with significant differences between various authorities on the validity of proposed new genera. This has resulted in new segregate genera proposed in *Caladenia* R.Br. *sens. lat.* (Jones *et al.* 2001) and *Pterostylis* R.Br. *sens. lat.* (Jones and Clements 2002) being disputed (Hopper and Brown 2004a; Hopper and Brown 2004b) and, subsequently, not being widely recognised by botanical taxonomic authorities in Australia.

Despite this situation, new species continue to be described in genera presently not recognised by State herbaria. For instance, 23 new taxa were described in *Arachnorchis* (Jones 2006a) (=*Caladenia sensu* Hopper and Brown 2004a) and 19 new taxa in *Bunochilus* (Jones 2006b) (=*Pterostylis sensu* Hopper and Brown 2004b) in 2006. This is an unfortunate situation as, without a validly accepted scientific name, newly described species cannot clearly be accommodated in official lists of a region's flora. A validly accepted scientific name also makes the process of listing threatened species under State and Commonwealth biodiversity conservation legislation easier, a necessary first step in implementing any required protection measures.

New combinations are made in *Caladenia* R.Br. (from *Arachnorchis* D.L. Jones & M.A. Clem.) and *Pterostylis* R.Br. (from *Bunochilus* D.L. Jones & M.A. Clem.) for those taxa occurring in Victoria. These combinations are made so a valid name can be included in the census of vascular plants of Victoria maintained by the National Herbarium of Victoria, and are central to the nomenclature adopted by botanists and legislative authorities in this State.

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New combinations

Caladenia ampla (D.L. Jones) G.N. Backh., *comb. nov.*
Basionym: *Arachnorchis ampla* D.L. Jones, *Australian Orchid Research* **5**: 50 (2006)

Caladenia ancylosa (D.L. Jones) G.N. Backh., *comb. nov.*
Basionym: *Arachnorchis ancylosa* D.L. Jones, *Australian Orchid Research* **5**:51 (2006)

Caladenia clavescens (D.L. Jones) G.N. Backh., *comb. nov.*
Basionym: *Arachnorchis clavescens* D.L. Jones, *Australian Orchid Research* **5**: 53 (2006)

Caladenia cremna (D.L. Jones) G.N. Backh., *comb. nov.*
Basionym: *Arachnorchis cremna* D.L. Jones, *Australian Orchid Research* **5**: 53 (2006)

Caladenia cretacea (D.L. Jones) G.N. Backh., *comb. nov.*
Basionym: *Arachnorchis cretacea* D.L. Jones, *Australian Orchid Research* **5**: 58 (2006)

Caladenia douglasiorum (D.L. Jones) G.N. Backh., *comb. nov.*
Basionym: *Arachnorchis douglasiorum* D.L. Jones, *Australian Orchid Research* **5**: 62 (2006)

Caladenia grampiana (D.L. Jones) G.N. Backh., *comb. nov.*
Basionym: *Arachnorchis grampiana* D.L. Jones, *Australian Orchid Research* **5**: 62 (2006)

Caladenia oreophila (D.L. Jones) G.N. Backh., *comb. nov.*
Basionym: *Arachnorchis oreophila* D.L. Jones, *Australian Orchid Research* **5**: 55 (2006)

Caladenia osmera (D.L. Jones) G.N. Backh., *comb. nov.*
Basionym: *Arachnorchis osmera* D.L. Jones, *Australian Orchid Research* **5**: 56 (2006)

Caladenia peisleyi (D.L. Jones) G.N. Backh., *comb. nov.*
Basionym: *Arachnorchis peisleyi* D.L. Jones, *Australian Orchid Research* **5**: 57 (2006)

Pterostylis crassa (D.L. Jones) G.N. Backh., *comb. nov.*
Basionym: *Bunochilus crassus* D.L. Jones, *Australian Orchid Research* **5**: 127 (2006)

Pterostylis diminuta (D.L. Jones) G.N. Backh., *comb. nov.*
Basionym: *Bunochilus diminutus* D.L. Jones, *Australian Orchid Research* **5**: 120 (2006)

Pterostylis loganii (D.L. Jones) G.N. Backh., *comb. nov.*
Basionym: *Bunochilus loganii* D.L. Jones, *Australian Orchid Research* **5**: 119 (2006)

Pterostylis macilenta (D.L. Jones) G.N. Backh., *comb. nov.*
Basionym: *Bunochilus macilentus* D.L. Jones, *Australian Orchid Research* **5**: 117 (2006)

Pterostylis montana (D.L. Jones) G.N. Backh., *comb. nov.*
Basionym: *Bunochilus montanus* D.L. Jones, *Australian Orchid Research* **5**: 118 (2006)

Pterostylis prasina (D.L. Jones) G.N. Backh., *comb. nov.*
Basionym: *Bunochilus prasinus* D.L. Jones, *Australian Orchid Research* **5**: 133 (2006)

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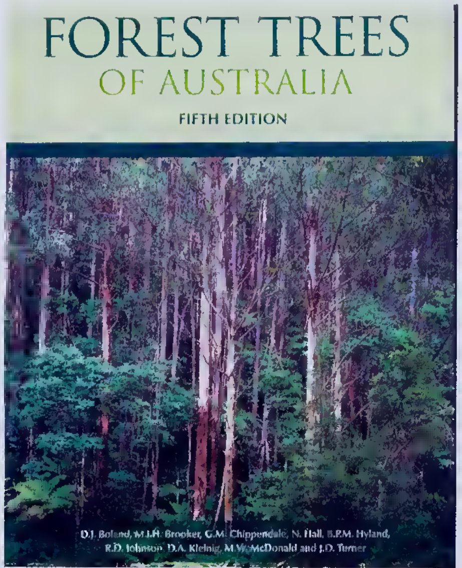
Forest Trees of Australia

by D Boland and eight other authors

Publisher: *CSIRO Publishing, 2006 (Fifth Edition). 768 pages, Hardback, 81 colour photographs, hundreds of black and white photographs. ISBN 0643069690. RRP $125.00*



Forest Trees of Australia first came on the botanical scene just fifty years ago. It was a relatively slim book covering just 67 species for the whole of Australia—all eucalypts, and even then, little more than a tenth of the eucalypt species count. Its title, and the originating authority (Forestry and Timber Bureau, Canberra), indicate its primary criteria for species selection, namely trees of economic value for their timber.

It was first published in 1957, and I owned an early copy, now long since vanished. In spite of its limited coverage for our area, it used a design style which I had always wanted in books of this type—a consistent treatment of every species with logical, systematic, concise descriptions, and clear, comprehensive illustrations, all on one page or spread, making it easy to compare species.

It also had another much-longed-for feature—distribution maps.

It was this book that inspired me to use a similar style of presentation, albeit simpler, in the first publication of *Trees of Victoria* in 1966.

Over subsequent editions, the number and diversity of genera and species steadily grew, as did the weight and price of the book, but the well-proven style of presentation has changed little.

This 5th edition gives its criteria for species inclusion as 'important to the timber industry, conspicuous in the landscape, of environmental value, or of ornamental interest'. In its 768 pages, it describes 178 eucalypts and 121 non-eucalypts (pines, sheoaks, figs, wattles, melaleucas, banksias, palms and many others).

The descriptions for every species incorporate comprehensive environmental information, associates, related species and taxonomic background as well as detailed description of all plant parts.

The photographs clearly illustrate all the critical plant parts and are in black and white. However, there are also about 80 colour plates of forest types and bark characteristics in the front of the book, preceding a 33-page introduction covering geology, summaries of the main tree families, and environmental and distribution factors. The book concludes with a good glossary supported by line illustrations.

What makes the 5th edition different from the 4th (1984)? Apart from the inclusion of 72 additional species treatments (including the unique and much publicised Wollemi Pine), there are many new photographs (including scanning electron micrographs), updated taxonomy, new supporting chapters, and revised distribution maps. The latter are 'spotted' from records, but at the scale of the maps can give only a broad picture compared with, say, *Flora of Victoria*.

Updating of taxonomy is an ongoing issue in any botanical publication, especially as some name changes come down to an individual botanist's opinion. For example, while most authorities have finally accepted *Corymbia* as a genus separate from *Eucalyptus* in the same way as *Angophora*, this book does not adopt this change (but does give *Corymbia* in synonymy). Hence the 'Corymbia confusion' continues!

My recommendation? There is no doubt that this is an accurate, reliable and well-presented book. Whether one would want

to pay the $125 depends on where one's interest in trees lies. From a Victorian viewpoint, most of the additional species are in remote parts of Australia, some with very restricted natural distribution; I couldn't see any extra species for the Victorian area. On the other hand, for the species it does treat, this book gives more information on environmental factors and timber characteristics than any other, and if this is interesting or important to the reader, the book is certainly recommended.

Leon Costermans
1/6 St Johns Ave
Frankston, Victoria 3199

Wild Neighbours: The humane approach to living with wildlife

by Ian Temby; illustrated by Elisabeth Bastian

Publisher: *Citrus Press, Broadway, NSW, 2005. 250 pages. Paperback ISBN 0975102354. RRP $36.00*

Have you ever had to deal with problem faunal species sharing your house and backyard? This book has all the answers for dealing with a complete range of would-be sharers from bandicoots to wombats and butcherbirds to wattlebirds. Even spiders rate a chapter in this comprehensive coverage of the creatures of our neighbourhoods.

Part 1 is a general coverage with sections on conflict resolution, to feed or not to feed, health issues, and tools and tactics to be used. Part 2 expands this. Each species or species group is assigned a chapter, which provides descriptions and background information on the species, their habitats and diets and their reproductive strategies. The problems that arise and suggestions for resolving these problems are discussed under the headings Tolerance, Exclusion, Repellents and Live Trapping. Tolerance is always the preferred option, whilst live trapping is not recommended except in extreme cases, and only where permitted by government agency or licensed operator.

Temby is sympathetic to wildlife, particularly species that may not be appreciated by humans, such as crows and ravens which are noted for their intelligence and problem-solving ability, or spiders, which 'can be considered a chemical free pest control service' and snakes, which are often senselessly killed regardless of their importance to the ecosystem. Often a species, such as Masked Lapwing, is admired for its successful adaptation to the urban environment.

Introduced species are also included, and while we may deplore their spread and displacement of our native species, they still add interest to a bland structured streetscape.

This is a very informative and useful book peppered with the author's humourous comments and anecdotal stories of interactions with wildlife. Overall, the emphasis is on how lucky we are to have native wildlife that is willing to share our habitat with us.

Anne Morton
10 Rupicola Crt
Rowville Vic 3178

CSIRO list of Australian vertebrates: a reference with conservation status. Second edition.

by Mark Clayton, John C Wombey, Ian J Mason, R Terry Chesser and Alice Wells
Publisher: CSIRO Publishing, Collingwood, 2006. 162 pages, paperback. ISBN 0643090754. RRP $59.95

To paraphrase the Bard: What's in a name? That which we call an Orange-bellied Parrot would be as threatened by any other name. That's not to say, of course that names are unimportant, and this is particularly the case with scientific names. And as with all areas of scientific study there is always a bit of movement going on. Hence there is a regular need to update the names and groupings of vertebrates.

This book is the second edition of a work that was originally published in 1998. As the authors say (p. 1), 'numerous changes in intervening years' in the taxonomy and nomenclature of Australian vertebrates make a new edition timely.

Most of those changes are reflected in this new edition, although some revisions in the higher level systematics of Australian vertebrates are not included. Having said as much, the authors do not indicate either what those changes were or why they haven't been included. However, this edition does provide information not presented in its predecessor. This includes detail of all currently recognised and named subspecies; distributional information for species found in all Commonwealth territories (e.g. Norfolk Island and Australian Antarctic Territory); more complete nomenclatural data for all species; and a supplementary table of vagrant and accidental mammal records.

The structure of the book is straightforward and easy to follow. It begins with an introductory section of general information, wherein are presented such matters as the rationale for the book, an explanation of the types of information the work contains, and details of the sources of background data upon which the core of the book is based. In the four sections that follow this introduction, the complete range of vertebrate animals is tabulated under general headings of amphibians, reptiles, birds and mammals. Within each of these sections, species are grouped together by family. These tables constitute the core of the book, with the conservation status of each animal indicated for all states and territories, by means of codes positioned in columns adjacent to the species' names. These four sections are followed by another new feature in this edition, an Appendix that provides details of all newly described and accepted taxa. Finally, all animals are indexed twice – separately by both common and scientific names, grouped in the same order as in the body of the book.

By its nature, this is not a book that one would pick up for a spot of light reading. However, it will be an invaluable reference tool for both professionals and interested amateurs in a wide range of contexts dealing with vertebrates in natural environments.

The review copy of *Australian vertebrates* can be found henceforth within the Reference section of the FNCV Library, where it will no doubt be sought regularly by the Editors of *The Victorian Naturalist.*

Gary Presland
School of Social and Environmental Enquiry
The University of Melbourne, 3010